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June
1931

SUMMER

CONVENTION

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JUNE 22 - 26 1931

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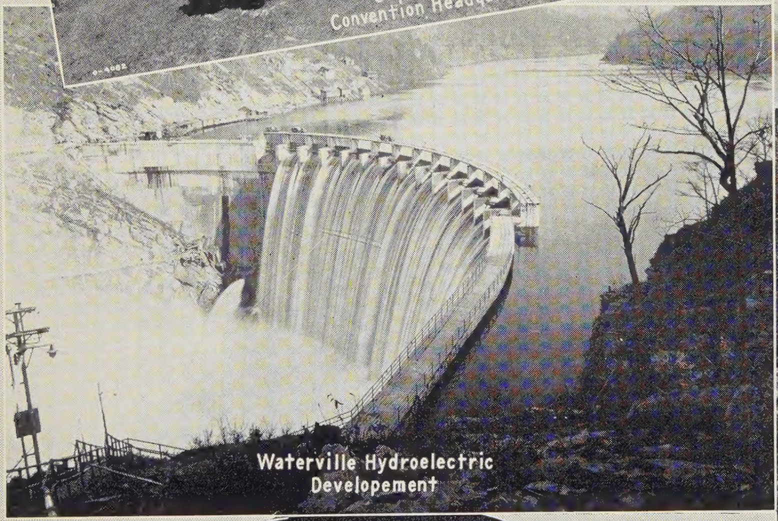
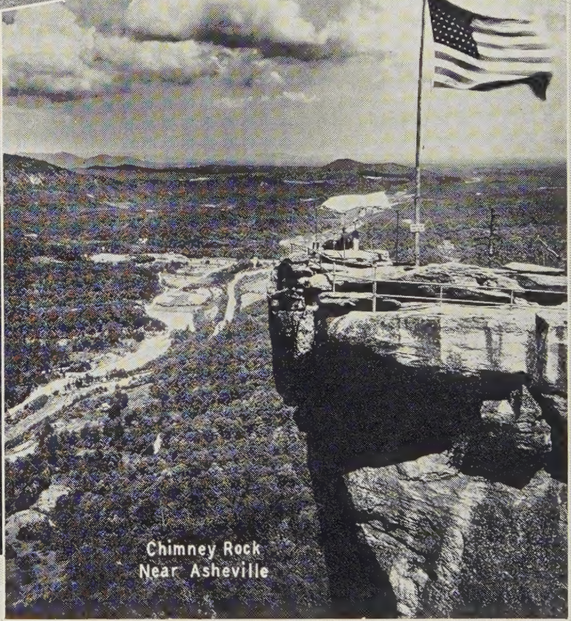
SUMMER CONVENTION

ASHEVILLE, N.C.
JUNE 22-26

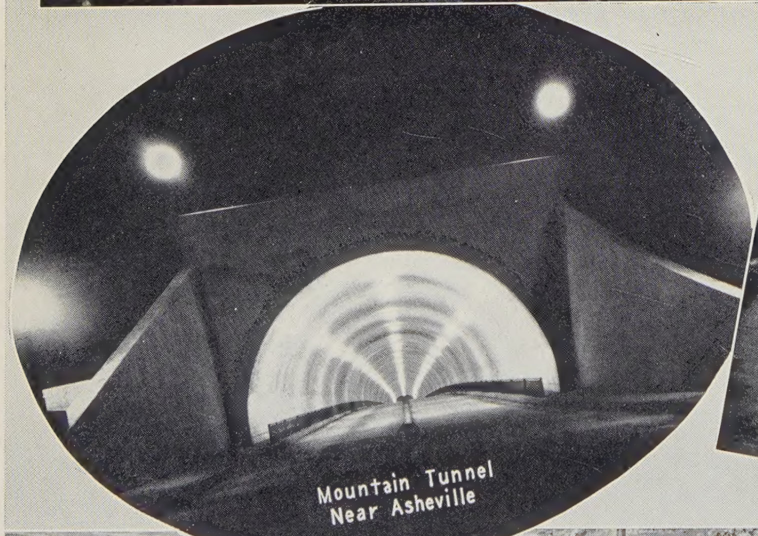
Grove Park Inn
Convention Headquarters



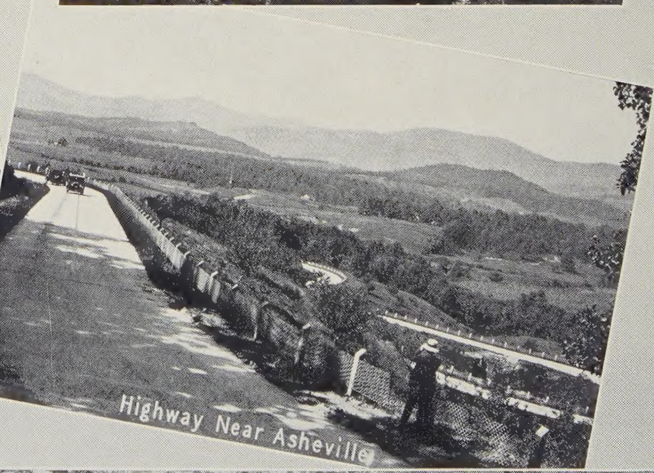
Waterville Hydroelectric
Developement



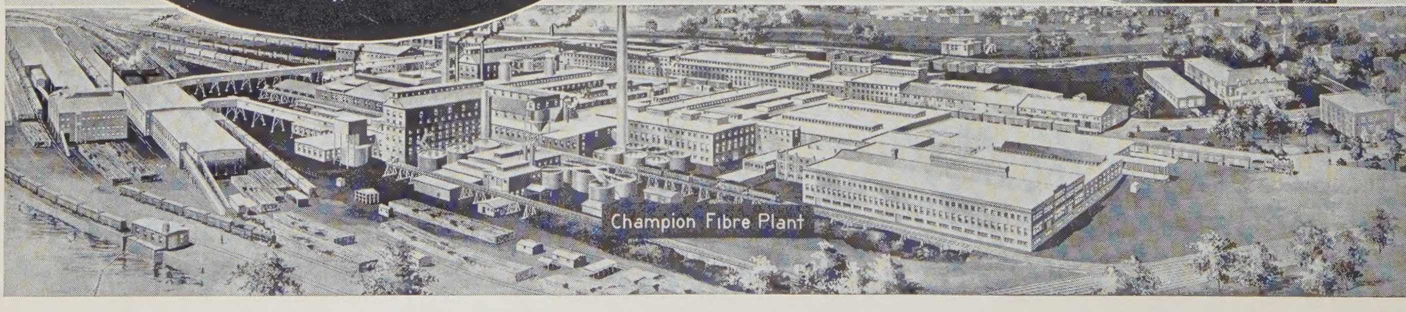
Chimney Rock
Near Asheville



Mountain Tunnel
Near Asheville



Highway Near Asheville



Champion Fibre Plant

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This Month—

Front Cover

Mt. Pisgah and The Rat, famous mountain group in the vicinity of the A. I. E. E. summer convention headquarters at Asheville, N. C.

"Nowhere are the skies bluer,
Nowhere do hearts beat truer,
And nowhere is friendship surer,
Than down in Carolina."

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Officers and Committees (For Complete list see pp. 81-84, January 1931 issue of ELECTRICAL ENGINEERING.)

R. M. STANLEY (F '23) in collaboration with C. T. Sinclair (M '29) describes the application of the network idea to medium- and low-load areas in the vicinity of Pittsburgh. (*See page 400.*)

ELECTRIC SHOCKS which do not involve the brain, respiratory nerves, or spinal cord seldom jeopardize life in animal organisms according to experimental findings discussed by W. B. Kouwenhoven (M '22) and O. R. Langworthy of Johns Hopkins University, Baltimore. (*See page 406.*)

EDWARD DEAN ADAMS, Associate of the Institute, Edison Pioneer, and energetic leader in engineering, financial, and philanthropic undertakings answers the Last Call, largely as a result of a recent automobile accident. (*See page 452.*)

SOUTHERN HOSPITALITY and the beauties of the Carolina mountains, often extolled by President Lee, should combine to attract many to the Institute's summer convention at the Grove Park Inn, Asheville, N. C. Incidentally there is offered a splendid technical program and, of course, the annual Mershon Trophy golf tournament. (*See page 440.*)

BETWEEN SYMPOSIA on noise and on lightning, the Rochester, N. Y., meeting of the North Eastern District enjoyed rather an animated program. In this issue there may be found a complete news story of the meeting and also a summary of some of the more pertinent discussions. (*See pages 441 and 445.*)

CONCERTED cooperative attack upon the central problems presented in present noise studies and investigations is being sought as an inter-society activity. Delegates attending a special joint meeting at Rochester, N. Y., attempted to reach common ground and succeeded in agreeing upon a statement of three fundamental questions. (*See page 443.*)

EDISON BUST was presented May 7 to the German Museum at Munich with fitting ceremony. (*See page 446.*)

PACIFIC COAST convention committee has arranged for extension of special rates at Tahoe Tavern, Lake Tahoe, California, as an aid to those who will spend their vacation there in connection with the convention. (*See page 449.*)

DR. CHARLES F. SCOTT, past-president of the Institute and long-time head of the electrical engineering department of Yale University, New Haven, Conn., is planning to retire. R. E. Doherty, formerly G. E. consulting engineer, has been appointed as his associate; will succeed him upon his retirement. (*See page 450.*)

STUDENTS participated actively in the Rochester, N. Y., district meeting; presented several interesting papers. (*See page 444.*)

FUTURE MEETINGS

of the

American Institute of Electrical Engineers

Place	*Dates*	*Nature*	*Latest Date for Receipt of Manuscripts*
Asheville, N. C.	June 22-26, 1931	Summer Convention	(Closed)
Lake Tahoe, Calif.	Aug. 25-28, 1931	Pacific Coast Convention	(Closed)
Kansas City, Mo.	Oct. 22-24, 1931	District Meeting	July 22, 1931
New York, N. Y.	Jan. 25-29, 1932	Winter Convention	Oct. 26, 1931
Milwaukee, Wis.	March 14-16, 1932	District Meeting	Dec. 14, 1931
Providence, R. I.	May - 1932	District Meeting	Feb. - 1932

NOTE: Members who are contemplating submitting papers for presentation at any of the above meetings should communicate promptly with Institute headquarters, 33 West 39th Street, New York, N. Y., so that their papers may be docketed for consideration by the Meetings and Papers Committee, as programs for all meetings are formulated several months in advance. Upon receipt of this notification, Institute headquarters will mail to each prospective author information in regard to the Institute's rules relating to the preparation of manuscript and illustrations.

MEETINGS OF OTHER SOCIETIES

NATIONAL ELECTRIC LIGHT ASSOCIATION, annual convention, Atlantic City, (A. J. Marshall, 420 Lexington Ave., New York) June 8-12, 1931.

SOCIETY OF AUTOMOTIVE ENGINEERS, summer meeting, White Sulphur Springs, W. Va., June 14-19, 1931.

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS, Cleveland, Ohio, (J. F. Kelly, Empire Bldg., Pittsburgh, Pa.) June 15-19, 1931

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE, summer convention, Pasadena, Calif., (Chas. F. Roos, Secy., Smithsonian Institute, Washington, D. C.) June 15-20, 1931.

NORTHWEST ELECTRIC LIGHT AND POWER ASSOCIATION, (annual convention, cancelled by action of Executive Committee, Portland, Ore., April 10, 1931).

INTERNATIONAL CONFERENCE ON LARGE HIGH-TENSION ELECTRIC SYSTEMS, Paris, France, (Dr. C. O. Mailloux, 111 Fifth Avenue, New York, N. Y.) June 18-27, 1931.

AMERICAN SOCIETY FOR TESTING MATERIALS, annual meeting, The Stevens Hotel, Chicago, (C. L. Warwick, Secy., 1315 Spruce St., Philadelphia, Pa.) June 22-26, 1931.

PACIFIC COAST ELECTRICAL ASSOCIATION, annual convention, Del Monte, Calif., (K. I. Dazey, 447 Sutter Street, San Francisco, Calif.) June 24-27, 1931.

ROCKY MOUNTAIN DIVISION N. E. L. A., annual convention, Stanley Hotel, Estes Park, Colo., Sept. 2-4, 1931.

ILLUMINATING ENGINEERING SOCIETY, annual convention, Pittsburgh, Pa., October 13-16, 1931.

The Primary Network for Medium-Load Areas

As a result of the noteworthy economic and operating success of the secondary a-c. network the same principle now is proposed for relatively high-voltage primary systems. Based upon economic studies of two Pittsburgh residential areas one primary network now is under construction there and a second all planned. Major details involved are given here and ten distinct advantages are enumerated.

By
R. M. STANLEY Fellow A. I. E. E — Byllesby Engineering & Management Corporation

C. T. SINCLAIR Member A. I. E. E. — Byllesby Engineering & Management Corporation

A NETWORK may be said to exist wherever the secondaries of two or more transformer banks not at the same location are connected in parallel to supply a common load. This definition is applicable to either high- or low-voltage systems. In this discussion a new design of primary network is considered which combines the principle of interconnecting 4-kv. mains and certain principles common to the design of secondary network, and which is fed directly at load-transmission voltage.

Generally speaking, the comparable characteristics of the older radial primary distribution system and the new primary network are as revealed in Fig. 1 and in Table I.

TABLE I—ELEMENTS OF A PRIMARY SYSTEM

Radial	Network
1. Transmission feeders from source of supply to substation	1. Transmission feeders from source of supply to substation
2. The substation	2. The transformers and switches
3. The distribution feeders	3. The primary mains
4. The mains	

From these it may be seen that the elements of the two systems are the same except for the elimination of primary feeders in the network design—an important item, but only one of several which permit a saving in initial cost as compared with the radial system.

In the typical radial system (Fig. 1) the substation is located of course as nearly as possible at the center of the expected load and each feeder terminates at its approximate load center. In the typical primary network of Fig. 1 the transformer capacity required for the entire area is distributed, each transformer at an intersection of primary mains and each intersection group constituting a unit, including regulators on transformer secondaries where and if required. Similar to the principle of secondary networks, it is desirable that the transmission supply to a given area comprise three or more feeders in order to reduce the spare capacity required to accommodate the possible loss of a feeder.

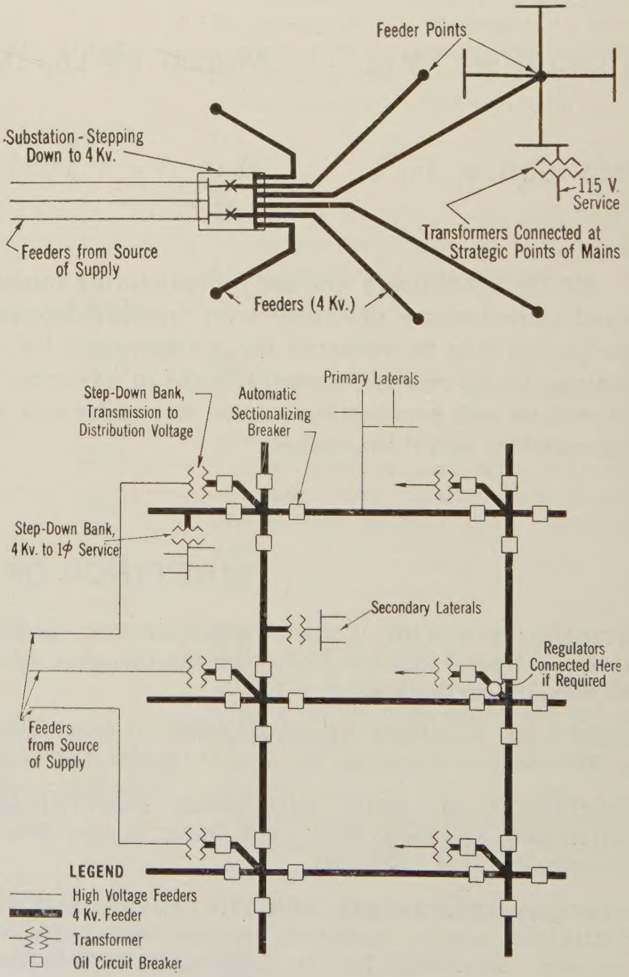
Feeder Points
Substation - Stepping Down to 4 Kv.
115 V. Service
Feeders from Source of Supply
Transformers Connected at Strategic Points of Mains
Feeders (4 Kv.)
Primary Laterals
Step-Down Bank, Transmission to Distribution Voltage
Automatic Sectionalizing Breaker
Step-Down Bank, 4 Kv. to 1ϕ Service
Secondary Laterals
Regulators Connected Here if Required
Feeders from Source of Supply
LEGEND
High Voltage Feeders
4 Kv. Feeder
Transformer
Oil Circuit Breaker

Fig. 1. Comparative schematic diagrams of typical radial system (above) and primary network system

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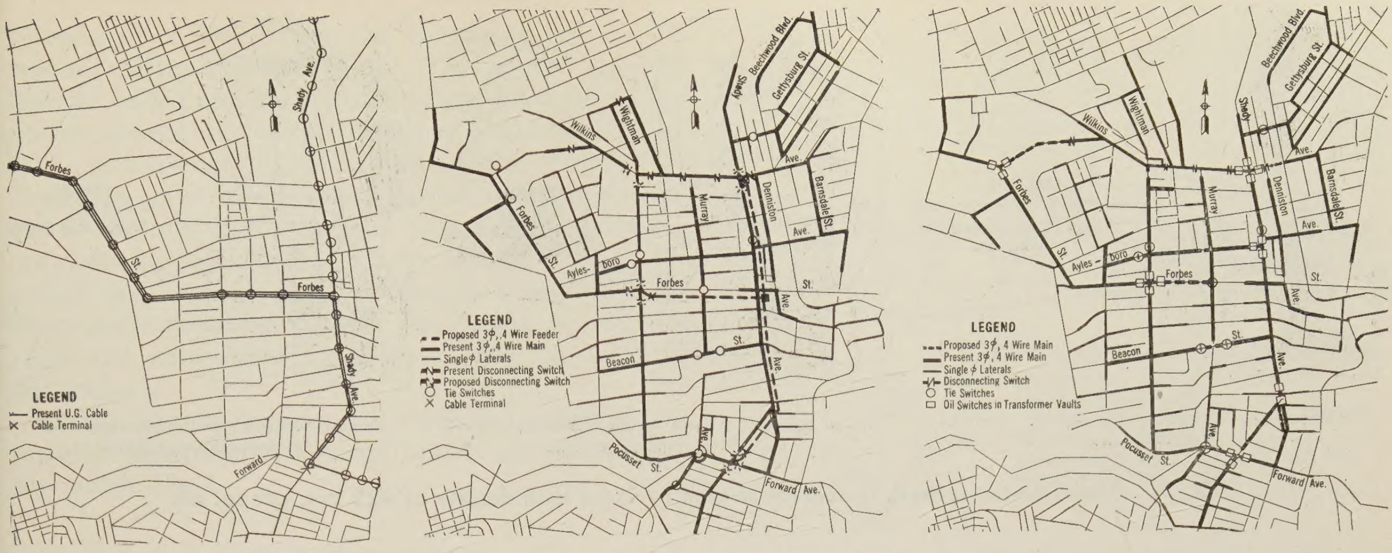
From "The Primary Network," (No. 31-55) presented at the A. I. E. E. Middle Eastern District meeting, Pittsburgh, March 11-13, 1931.



Three transmission feeders available in the area to supply either system

Radial primary system which ordinarily would be used to supply the area

Diagram of mains for primary network showing distributed transformer points

Fig. 2. Radial versus network system for an area having a load density of 2,100 kva. per sq. mi.

Comparative Cost Estimates for Area of 2,100 Kva. per Sq. Mi.

To secure practical working data revealing the actual relative economies of the two systems, two different areas in the Pittsburgh district were studied exhaustively. Load growth in both areas required early attention to increased distribution capacity, and these comparative studies involved consideration of existing facilities as well as required extensions.

The initial study covered a residential section known as Squirrel Hill, which includes a few apartment houses and a small business district but no industrial load of any character. The area embraces about two square miles, has a winter peak load of some 4,200 kva., and a load density of 2,100 kva. per sq. mi. At present this area is fed by circuits from two adjacent areas; it was chosen for the initial economic study because (1) it had relatively definite boundaries and no existing substation and (2) load growth indicated the early necessity of extending the radial system materially or adopting a new system. (See Fig. 2.)

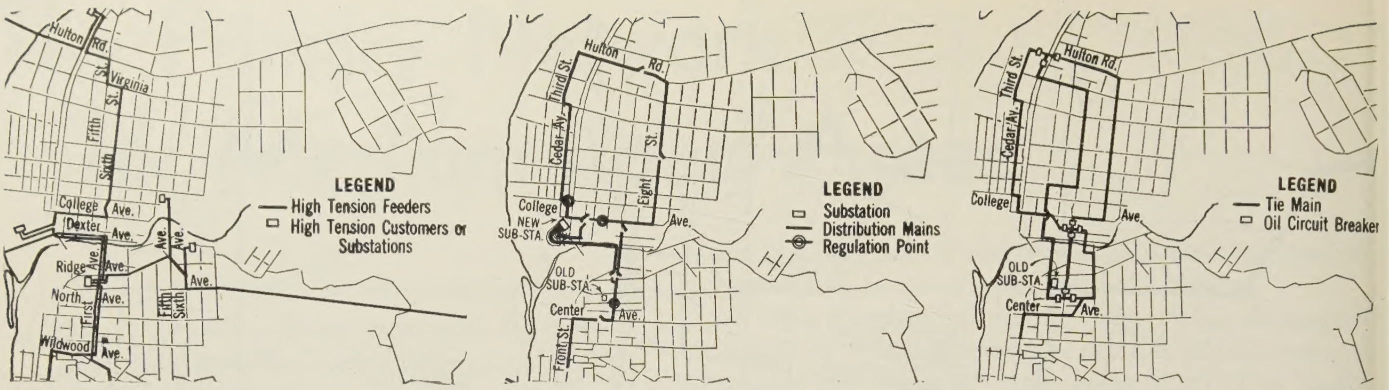
Estimates for extension of the radial system are based upon standard practise in the Pittsburgh district. The necessary substation proposed is a semi-outdoor 22/4-kv. full-automatic type similar to others on the Duquesne Light Company system. Its proposed location was chosen as the result of an economic study of the sites permitted by zoning ordinances, and is reasonably near the expected load center of the area. Initial installation would consist of two 4,000-kva. transformer banks, a 22-kv. tie breaker, three 300-ampere 4-kv. regulated feeders, and related equipment. The building would provide space for an ultimate of two 6,000-kva. transformer banks and five feeders.

The primary network includes exactly the same area and supply from the existing transmission feeders. Transformer and switching units contemplated are the submergible type planned for installation in street vaults. The transformers are 1,500-kva. 22/4-kv. three-phase units with four 2.5 per cent taps below 22-kv. and two similar taps above, and with a three-position disconnecting and grounding switch on the 22-kv. side. The transformer oil circuit breaker is integral with the transformer and comprises a 7.5-kv. 600-ampere unit rated at 14,000 amperes rupturing capacity at 4 kv., 2-OCO. The tie main breakers are similar and they will be arranged to reclose once on a fault, the breakers at each end of a faulty section closing at different times to provide the equivalent of two reclosings. Lead-covered cable is figured in for all 4-kv. work in the vaults and also duct connections between existing manholes and the proposed transformer vaults. Cables are planned to run in pipe from the vaults to the several poles at the related intersection, terminating there in disconnecting potheads.

Both the primary network and the radial plans provide for an operating capacity of 7,500 kva. Primary feeder and duct costs are common to both plans; hence were omitted from the comparison. Relative costs of the two plans as outlined are given in Table II where it may be noted that extension of the radial system will cost 78 per cent more than a change over to the primary network plan. The inherently better voltage regulation of the network is expected to obviate the necessity for regulators.

Comparative Cost Estimate for Area of 425 Kva. per Sq. Mi.

The Verona-Oakmont area was the second to be studied to determine the relative economies of the radial



Transmission feeders available in Verona-Oakmont area

Radial primary system which ordinarily would be used to supply the area

Primary network mains showing three transformer installations

Fig. 3. Radial versus network system for an area having a load density of 425 kva. per sq. mi.

versus the primary network system. In spite of the fact that the area embraces a total of 4.7 sq. mi. with a total load of only 2,000 kva., or a load density of some 425 kva. per sq. mi., the economies figured out so predominantly in favor of the network that the proposed substation was abandoned and the area converted to a 4-kv. primary network. The network construction is rapidly nearing completion. Also the area in question is of a residential character, with a light commercial load now served at 2.3 kv.

TABLE II—COST COMPARISONS FOR AREA OF 2,100 KVA. PER SQ. MI.

	Radial	Network
Initial Step		
Load	4,200 kva.	4,200 kva.
Transformer capacity installed	8,000 kva.	9,000 kva.
Transformer capacity with spare capacity out of service	5,000 kva.	7,500 kva.
	Costs in per cent	
Real estate	18.0	0.0
Substations	21.0	26.7
Electrical equipment	67.0	56.0
Transmission	1.2	1.5
Distribution	18.4	3.4
Ducts	4.7	10.8
Changes in 4-kv. feeders and mains	0.0	1.1
Total initial step	130	100
Second Step		
Load	7,500 kva.	7,500 kva.
Transformer capacity installed	12,000 kva.	9,000 kva.
Transformer capacity with spare capacity out of service	7,500 kva.	7,500 kva.
	Costs in per cent	
Substation increase	28.0	0.0
Distribution increase	20.5	0.0
Total second step	178	100

Note: Radial system (initial step) will have two 4,000-kva., three-phase, transformers. With one out of service, the other will carry 25 per cent overload through peak or 5,000 kva., which is satisfactory for initial step and allowing for growth.

Network will have six 1,500-kva., three-phase banks and when one transmission line goes out, two 1,500 kva., banks go out also, leaving 6,000 kva. in service which, with 25 per cent overload capacity, gives 7,500 kva. capacity to carry 4,200 kva. initial load.

In the comparative studies of the Verona-Oakmont area a new substation having two 3,000-kva. transformer banks (giving a rated station capacity of 3,750 kva. allowing for 125 per cent load on one bank with the other out) would be the minimum requirement for extension of the radial system. This system also would have required two 4-kv. regulated feeders. (See Fig. 3.)

For the same area the network plan was figured upon three different bases; with:

1. All equipment in underground vaults.
2. Equipment above ground in small buildings.
3. Equipment mounted above ground and outdoors on concrete pads.

Calling the cheapest of these methods (3) 100 per cent, data revealed that the radial scheme represented 35 per cent addition in cost. The underground vault network plan (1) and the small-building plan (2) figures respectively 18 and 7 per cent more costly than plan(3). Comparative data are given in Table III.

TABLE III—COST COMPARISONS FOR AREA OF 425 KVA. PER SQ. MI.

	Radial	Network		
		U. G. Vault	Bldg. Type	Outdoor
Load	2,000 kva.	2,000 kva.	2,000 kva.	2,000 kva.
Proposed inst. capacity	6,000 kva.	4,500 kva.	4,500 kva.	4,500 kva.
Operating capacity*	3,750 kva.	3,750 kva.	3,750 kva.	3,750 kva.
	Costs in per cent			
Real estate	17.0	0.0	2.8	2.8
Substation bldg. or vault	4.2	24.5	13.0	5.8
Equipment	95.0	71.0	66.3	66.3
Transmission	2.5	3.3	4.4	4.4
Distribution	1.6	13.2	13.2	13.2
Duct connections	14.5	5.7	7.5	7.5
Total†	135.	118.	107.	100.

*Based on 125 per cent load on transformers for five hours in case of feeder or transformer failure.

†Note: Cost of regulators included in above estimates.

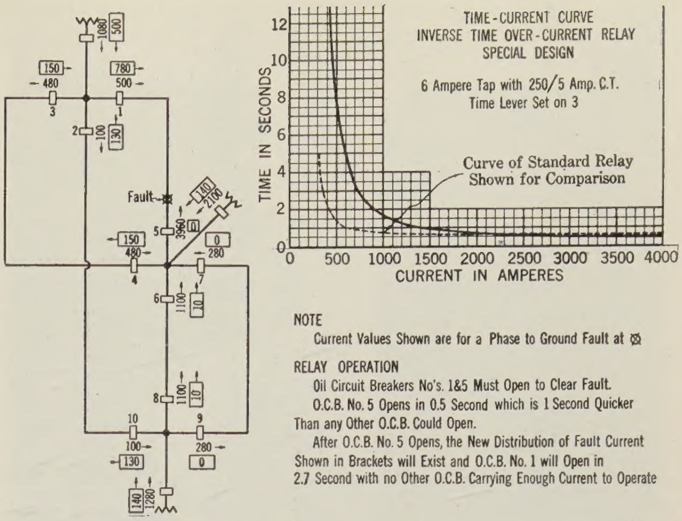
In pursuing the construction of the Verona-Oakmont primary network it was decided to use one each of the three kinds of installations just mentioned, in order to secure practical operating data. This worked out well because only three transformer points are required for the initial network. As to the future, it is contemplated that underground vaults may be used as required in congested areas where above-ground installations are out of the question because of proper costs or zoning ordinances. Small buildings may be used in less congested and medium-grade residential areas while in lower-grade areas the outdoor equipment on concrete pads and surrounded by a fence may be used to advantage.

In the area in question the vault will require submergible equipment. General details are revealed in the sketch, Fig. 4.

Relay Protection

Network relays similar to those used on low-voltage a-c. networks and providing similar protection are being used on the transformer breakers. Another relay recloses the breaker automatically upon resumption of supply on the feeder. Further protection in the form of a contact-making thermometer is being considered as a guard against protracted overloads. Bus differential protection at each transformer installation will operate to lock all breakers open in case of a fault on the bus at the intersection.

Tie-main protection has been the subject of extended investigation as a result of which overload relays with inverse-time characteristics greater than normally employed have been chosen for the service. With a 400/5-ampere current transformer and a 4-ampere relay tap, the relay will operate in 9 sec. at 480 amperes, and inaccurately on a current as low as 320 amperes. In the plan adopted only the two breakers connected to the faulty line will operate. However, if corner transformers are installed from which tie mains run in only two directions, proper selectivity is impossible with that particular transformer out of service. In general it may prove advisable not to use this design, but rather to run a third tie main to an adjacent intersection.



NOTE

Current Values Shown are for a Phase to Ground Fault at ⊠

RELAY OPERATION

Oil Circuit Breakers No's. 1&5 Must Open to Clear Fault.

O.C.B. No. 5 Opens in 0.5 Second which is 1 Second Quicker Than any Other O.C.B. Could Open.

After O.C.B. No. 5 Opens, the New Distribution of Fault Current Shown in Brackets will Exist and O.C.B. No. 1 will Open in 2.7 Second with no Other O.C.B. Carrying Enough Current to Operate

Fig. 5. Typical analysis of relay operation for tie-main fault

To determine definitely the requirements of a type of relay for this service, extensive short-circuit studies were

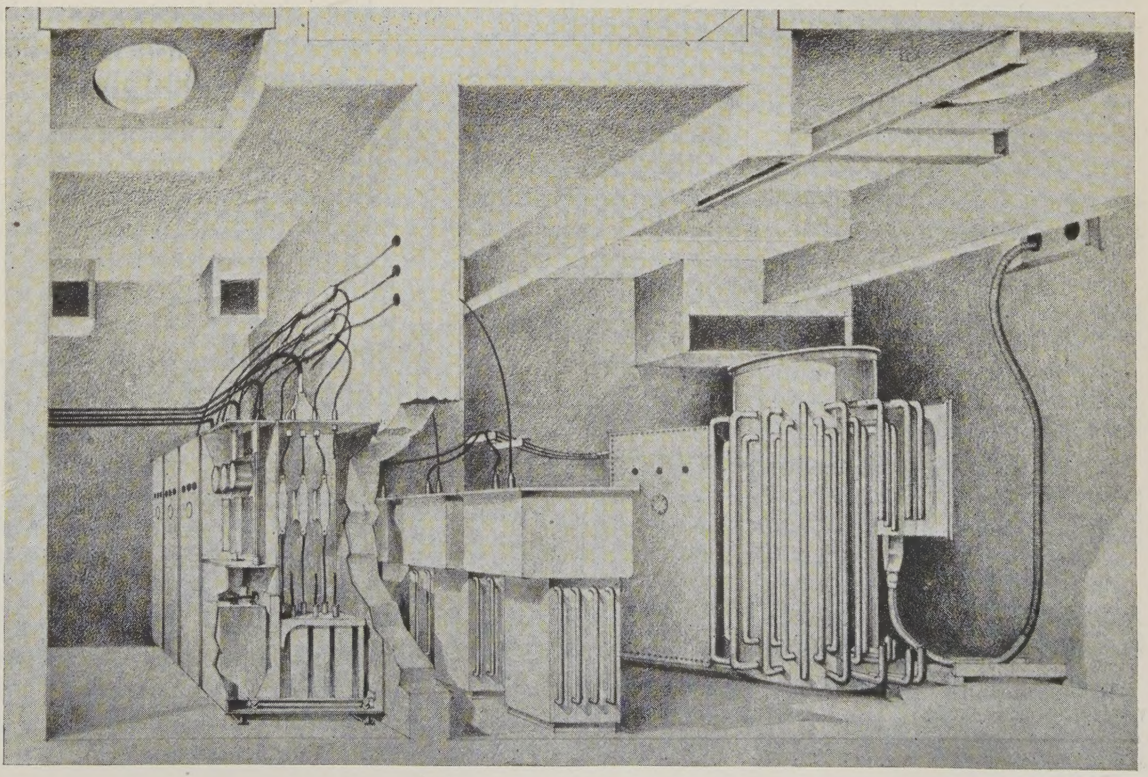


Fig. 4. Design features of underground primary-network vault showing barrier-wall construction for equipment segregation and showing also the integral construction of the transformer and its associated switching and relay equipment. Watertight hoods on (possible) regulators and watertight cubicles for breakers and all associated equipment also may be noted

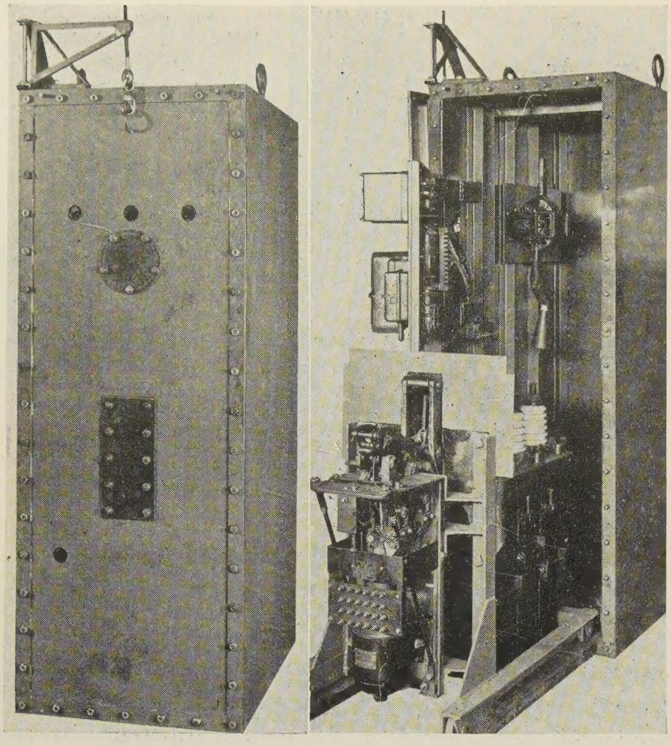


Fig. 6. Submersible cubicle for oil circuit breaker and associated equipment including relays

made of the network layout for three-phase and phase-to-ground faults at all locations along the tie mains, with all transmission feeders in service, and with each one out. Fig. 5 presents a typical analysis. Results in all cases are sufficiently conducive to warrant the expectation that no trouble will be experienced in relaying the Verona-Oakmont primary network, particularly if two-way-feed transformer installations can be eliminated.

Conclusions

On the basis of studies made, the primary network may be said to offer the following advantages over the usual radial system:

1. Material reduction in investment.

Even under the adverse conditions of load densities as low as 425 kva. per sq. mi., the cost runs as much as 35 per cent higher for the radial system.

2. Greater copper economy.

Reduced copper sizes are possible on the mains because of the smaller currents and shorter distances of feed, the results of the network principle.

3. Reduced duty on oil circuit breakers.

Short-circuit studies of the two areas studied and of theoretical systems indicate that the oil circuit breakers can be materially smaller than for the corresponding radial system.

4. Better regulation.

Any radial system inherently has considerable voltage variation which regulators cannot compensate. It is believed from a theoretical voltage analysis made that a very uniform voltage will be obtained on the network.

5. Small and standardized transformer units.

Transformer units (transformers, switches, regulators, if used, and auxiliary equipment), can be manufactured in units, stocked if necessary, and installed when required.

6. Capacity may be installed in small increments.

The radial system requires a substation and distribution system to be built well in advance of the load growth; long-range estimates are necessary for load growth both in direction and magnitude. In the primary network transformer units are installed where and when needed. Long-range predictions are unnecessary.

7. Investment for load growth in small increments.

The investment is not made in large steps far in advance of the load growth.

8. Reduced system losses.

One item of saving for example, is the complete elimination of feeder losses; there are no feeders.

9. Reduced area of outage.

With the designs considered each tie main will have a capacity of 600 or 700 kva.; the radial circuit has a capacity of 2,100 kva. A failure in the network therefore involves less than one-third the load of the radial system.

10. No 22-kv. breakers.

High-voltage cables run directly to the network transformers.

Vacuum Tubes and Their Applications

The extensive use of the high-vacuum tube in radio and communication work has resulted from certain remarkable characteristics of these tubes; the "thyratron" has been shown to possess certain other characteristics which mark it as being equally well suited to industrial uses.

By
W. C. WHITE
Member A. I. E. E.

General Electric Co.,
Schenectady, N. Y.

VACUUM TUBES may be classified according to (1) number of electrodes (a two-electrode tube, being termed a diode, a three-electrode tube a triode, and so on, to include tetrode and pentode); (2) content of the bulb, which may be high vacuum, gas, or vapor; (3) nature of the fundamental electrode, the cathode, which may be thermionic, photoelectric, mercury-pool, or cold.

For convenience, practically any form of the many types of vacuum tubes can be classified by a combination of these three properties. For instance one sold under the trade name of "tungar" is a gas-content, hot-cathode diode. Screen-grid tubes used so much in modern radio are hot-cathode, high-vacuum tetrodes. The small tubes which are sold under the trade name of "thyratron" are hot-cathode, mercury-vapor triodes.

HIGH-VACUUM TUBES

Fundamentally, the amount of current that can be carried through the vacuum in a hot-cathode, high-vacuum tube is dependent upon the electron emission and space charge effect. The electron emission is known to depend upon many contributing factors while the space-charge factor is controlled by simply introducing a grid into the tube with the proper voltage applied.

In a high-vacuum tube are embodied four features that singly or in combination make for a unique electrical device:

1. Independence of frequency.

The speed of electrons is such that they will respond to frequencies of the order of several million cycles per second, so that for most purposes the tube has no limitations in this respect.

2. Continuous control.

The electrons each carry such a small charge and are in such rapid motion that the current through the tube can follow accurately a very complicated wave form, as distinguished from the step-by-step action which occurs in most other electrical apparatus. This feature has made the high-vacuum tube useful in long distance telephony and radio broadcasting.

3. Voltage control.

Relatively large amounts of current through the tube can be controlled by the grid voltage without furnishing any current to the grid. For example, the electricity generated by rubbing a fountain pen with a piece of cloth, when applied to the grid is sufficient to control relatively large amounts of power. This feature provides for the high amplification common to this type of tube.

4. Rectification.

Current passes through the tube only when the cold electrode is positive with respect to the hot electrode.

From the point of view of these four factors, it may readily be seen why the high-vacuum tube is of such importance in radio. For industrial application, however, the high-vacuum tube has certain serious limitations, these being due mainly to high power loss within the tube. Part of this loss is represented by the power required to heat the cathode to the point at which electron emission will take place; this ranges from about 10 to 150 watts per ampere of current passed through the tube. Another limitation arises from the fact that from several hundred to about one thousand volts per ampere is required to force the current across the vacuum within the tube.

From these facts it will be seen that currents of more than a few amperes cannot be handled economically by means of this type of tube. Therefore, it is apparent that in the industrial field the most promising applications of the high-vacuum tube is in various control operations where the determining factor is the unique characteristics of the tube rather than its output.

THE THYRATRON

Next discussing the thyratron tube, its striking characteristics are the greatly decreased amount of power required to heat the cathode, and a marked reduction in the large voltage drop characteristic of the high-vacuum tube. This is brought about by the introduction of a slight amount of mercury gas or vapor into the bulb, the positively-charged vapor or gas molecules mingling with the electrons and neutralizing the space-charge. This neutralization of the space-charge makes possible a very different design of hot cathode; instead of utilizing what might be termed an open-type cathode permitting the electrons to leave the hot surface easily there may be used an enclosed-type cathode with just a few holes through which the stream of neutralized and negative ions may pass. This means that the heat may be kept within and conserved, whereas the electrons and positive ions may be allowed to travel to the anode. This is accomplished by surrounding the hot cathode with heat insulation and heat reflectors with only relatively small holes for the passage of the current. The resultant power loss is only about one watt per ampere of current through the tube contrasted with from 10 to 150 watts per ampere in the high-vacuum tube.

Also, neutralization of the space-charge eliminates the high voltage necessary to pass the current through the space; and instead of a large voltage increasing with the amount of current to be carried there is a constant-voltage drop of from 10 to 20 volts.

As a result a thyratron tube built to about the same physical size as the commonly-known UX-250 high-vacuum tube, and costing about the same amount to manufacture, will handle about 50 times as much current as the latter. It is apparent therefore, that the gaseous type of electrostatically-controlled tube is much better suited to the handling of relatively high currents common in the broad field of electrical engineering than is the controlled high-vacuum type.

Nevertheless, a thyratron tube has certain limitations; as stated, the high-vacuum type can handle currents up to a frequency of one million cycles per second, whereas the thyratron in its present form is limited to a few thousand cycles per second. Also the thyratron cannot control direct current in the same simple way as the high-vacuum tube; that is, it lacks the feature of "continuous control." These, however, are not serious drawbacks for most industrial uses and it appears that even as the characteristics of the high-vacuum tube fitted it remarkably into the radio communication field, so the thyratron tube may be considered equally well adapted for use in the industrial engineering field.

From a paper "Vacuum Tubes, Their Industrial Applications," presented informally at a meeting of the Schenectady Section of the A. I. E. E., Jan. 16, 1931. Reprints not available.

What are Effects of Electric Shock?

Are brain cells injured when currents do not pass through the head? What influence upon life continuity does the current path through the body have? In an effort to approach an answer to these and related questions a second set of experimental data is given herewith.

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IT IS WELL RECOGNIZED that the point of bodily contact is a factor of great importance in cases of injury resulting from exposure to energized electric circuits. Physical danger to vital body tissues is the source of greatest danger to life continuity in cases of electric shock, and the location of the point of contact determines largely the pathway of current flow. Once inside the body the current spreads out in a more or less fusiform shape, but it is difficult to believe that the current density can be high in organs distant from the most direct path between points of contact. For example, if a man makes contact with an electric circuit through one arm and one leg, it is scarcely possible that any appreciable current will pass through his brain.

Review

Before proceeding further with the present discussion it may be well to recapitulate briefly because earlier experiments reported upon[1] (for numbered references, see bibliography) brought to light certain facts which apply to the present series.

In the earlier tests electrodes were applied only to the head and tail of the animal subjects. Rats were used as the experimental animal and both continuous- and alternating-voltage shocks were administered at 110, 220, 500, and 1,000 volts. At each voltage the duration of contact at first was short and subsequently increased until it was impossible to resuscitate the subject by means of artificial respiration. These tests revealed that:

1. A 1,000-volt continuous current was more dangerous to rats than an alternating current of the same effective voltage.
2. A large rat survived a greater shock than a small rat.
3. Both sexes were equally susceptible to electric shock.
4. Paralysis of the hind legs resulting from hemorrhages in the spinal cord characterized many of the a-c. experiments.

With the electrodes on head and tail the brain was directly in the current path and the studies showed that the brain appeared to be injured readily by the passage of an electric current through it. Subsequent to the death of the rats evidences of nerve-cell damage and of both macroscopic and microscopic hemorrhage in the brain were found in many instances.[2]

In legal electrocution one electrode is placed on the skull, but industrial accidents rarely involve head contact; the common path is from hands to feet.[3]

Recent Experiments

The recent series of experiments was undertaken to study the influence of the current path upon the effects produced by an electric shock. Are injuries to brain cells produced when the current does not pass through the head? Rats again were chosen as animals for study because of accurate knowledge of their behavior and because a rat seldom if ever dies of damage to heart after an electric injury, but rather from respiratory failure. Using a 1,000-volt circuit, 102 rats were shocked, half with a-c. and half with d-c., each for a period of two seconds. Electrode positions were varied and a few tests were made with the electrodes on the head and tail of the animals to check the results of the prior series.

Preparatory to the shock the rats were given ether until they were quiet, then the points of contact were moistened thoroughly with saline solution and the electrodes (voltmeter clips filed smooth) attached. When connection was made to the head a special electrode was employed which made contact only on the upper surface of the skull and did not interfere with breathing. After the electrodes were in place the shock was applied. In each case the circuit was held closed for exactly two seconds and the current flowing through the animal was recorded.

Immediately following the shock, the animal was removed from the circuit and if there was no evidence of breathing, artificial respiration was applied. This consisted of the application of digital pressure upon the chest, reproducing so far as possible the Schaefer prone-pressure method. Also the tongue was pulled out, the vagus nerves in the neck were stimulated by stroking with the fingers, and efforts were made to keep the respiratory tract free from mucus.

Following the a-c. injuries the chest of the animal was fully expanded, a seemingly important aid to the resumption of spontaneous breathing or to adequate artificial respiration. However, after contact with the d-c. circuit the chest was collapsed and it was difficult to get air into the lungs. The a-c. shocks produced a strong contraction of musculature of the body and this in the cases of males was accompanied almost invariably by an emission. Clonic movements of the muscles of the leg were observed in many of the a-c. injuries, probably produced by irritation of the nerve cells due to asphyxiation. Bleeding of the conjunctiva also occurred in many cases.

Electrodes on Head and Tail

Six rats in the present series and ten in the prior series were subjected to a two-second contact with a 1,000-volt a-c. circuit with electrodes affixed to head and tail. Artificial respiration was required and applied in 88 per cent of the cases, and five or 31 per cent recovered. The others died or were paralyzed by the shock. Three of the five that recovered were normal. After breathing was established it was rapid, shallow, and somewhat irregular for several hours following the injury, later becoming normal.

Only one of the six rats in the present series was paralyzed as against five of the ten in the prior series; in fact in the present group paralysis was less common and fewer hemorhages in the spinal cord were found than in the tests of a year ago although no explanation for the discrepancy can be given. A brief analysis of tabulated results shows that:

1. Of the five subjects to recover, the average weight was 217 grams and the average body current 0.848 ampere.
2. Of the six paralyzed subjects, the average weight was 242 grams and the average body current 0.800 ampere.
3. Of the five subjects which died, the average weight was 161 grams and the average body current 0.844 ampere.

In the tests previously published no rat survived a contact of one second or more with a d-c. circuit of 1,000 volts. Therefore, in this series only two animals were given a two-second shock at this voltage and neither of them survived although their hearts beat strongly for several minutes following the contact. Autopsy showed only few abnormalties, but microscopic examination of the brains of the rats of the prior series revealed that the current had caused nerve-cell injuries incompatible with life.

Observations in the present group check with those of the prior experiments where the electrodes were applied to the head and tail of the animal. It is clearly evident that contact with a 1,000-volt d-c. circuit is much more deadly to a rat than contact with an a-c. circuit of the same effective voltage. In this series, artificial respiration was applied to all of the animals tested with continuous current, and 100 per cent of them died. In the a-c. tests, however, artificial respiration was needed in only 88 per cent of the cases; 31 per cent of the animals died, 38 per cent were paralyzed, and 31 per cent recovered from the injury.

Electrodes on Right Fore Leg and Tail

Twelve rats were given a two-second 1,000-volt a-c. shock with electrodes on the right fore leg and tail. Five of these rats breathed as soon as the circuit was opened; in the other seven cases artificial respiration was required. Death occurred either immediately or within a few minutes in 42 per cent of the cases; three rats were paralyzed, one of which died four hours after the injury, another, nine hours, and the third survived until killed preparatory to autopsy.

This group was of particular interest in emphasizing the fact that an animal was not necessarily on the road to recovery when breathing was first started. This phenomena is mentioned often in records of human electric shock. Breathing was started in three of the rats only to cease after a few minutes and a second application of artificial respiration saved only one. Several of the rats in this group were hyper-irritable to all sensory stimuli for some minutes following the injury. Bleeding from the eyes was a common occurrence. The paralyzed rat that survived had a hemorrhage in the spinal cord and there was no chance of its permanent recovery.

With the alternating current flowing through the animals from right fore leg to tail 35 per cent of them recovered, 42 per cent died, and 25 per cent were paralyzed. The injury was slightly less severe than when the brain formed part of the current path as in the previous series.

Another twelve rats were tested on a continuous-current circuit with electrodes also on the right fore leg and tail. In this test the brain did not lie directly in the path of the current and the results were vastly different from those where one contact was made with the top of the skull. Here six of the rats breathed spontaneously when the circuit was opened, whereas none were saved in the first series even after long applications of artificial respiration. There was only one rat in this group of twelve that did not attempt to breath after the injury.

Artificial respiration was applied in 50 per cent of the d-c. cases; 42 per cent recovered; 25 per cent died, and 33 per cent were paralyzed; but these figures do not tell the whole story. Burns resulting from contact with direct-current were much more severe than those observed with alternating current. Because of these burns it was not possible to keep any of the surviving animals alive for a period longer than three days following the d-c. shock. However, any rat that survived an a-c. shock without paralysis appeared quite normal 24 hours later; they ate, drank, and were active. It is of interest also to note that in this d-c. group there were two cases where breathing was started only to stop again. In both of these instances a second application of artificial respiration was unsuccessful. Further brief analysis of tabulated results of this group of tests involving 24 rats shows that:

1. Of the four subjects which recovered from a-c. shock the average weight was 171 grams and the average body current 0.767 ampere; of the five recoveries from d-c. shock, 108 grams and 0.754 ampere.

2. Of the three subjects paralyzed by a-c. shock the average weight was 179 grams and the average body current 0.743 ampere; of the four paralyzed from d-c. shock, 130 grams and 0.887 ampere.

3. Of the five subjects dying from a-c. shock the average weight was 174 gram and the average body current 0.718 ampere; of the three succumbing to d-c. shock, 103 grams and 0.800 ampere.

From these results it is clearly evident that in cases where the continuous-current path does not include the brain there is at least a fifty-fifty chance of resuscitating the animal.

ELECTRODES ON LEFT FORE LEG AND TAIL

Twenty-four rats were tested with the electrodes on the left fore leg and the tail, half with alternating and half with continuous current. Under alternating current, artificial respiration was applied in 75 per cent of the experiments; 58 per cent recovered, 17 per cent were paralyzed, and 25 per cent died. With direct-current, artificial respiration was used in only 58 per cent of the cases; 42 per cent recovered, 33 per cent were paralyzed, and 25 per cent died.

The results of this series also emphasized the fact that breathing will not necessarily continue after having been established either spontaneously or by artificial respiration. Reactions and behavior of the rats in this group were closely identical with those where the current path was from the right fore leg to the tail. It was not, however, quite so dangerous to life. The d-c. results here also confirm the importance of eliminating the brain from the current path if any hope of recovery for the animal is to be entertained.

ELECTRODES ON BOTH FORE LEGS

Eight rats were tested with electrodes on both fore legs, thus involving the heart and lungs directly in the path of the current flow; four were shocked with alternating, and four with continuous current; their average weight was 144 grams and the average body current was 1.24 amperes.

Although artificial respiration was tried in every case, no animal survived, a fact not strange when one considers the current that flowed for two seconds. The chest was warm to the touch when the circuit was opened. In all but one case, however, the heart continued to beat following the shock. It is remarkable that there was any heart beat at all after so severe an injury, and that two of the rats attempted to breathe following the a-c. contact and two following the d-c. contact. There is no possibility of survival with this current path.

ELECTRODES ON BOTH HIND LEGS

Fourteen rats were tested at 1,000 volts with electrodes attached to both hind legs, seven on an a-c. circuit and seven on a d-c. circuit. Their average weight was 127 grams and the average current that flowed for two seconds was 1.17 amperes. Only one rat died as a result of the a-c. contact, and two from the d-c. contact, when the circuit path involved principally the caudal region of the body. The rat that died after the a-c. contact had started breathing spontaneously as soon as the circuit was opened. He was considered as recovered and had been placed back in the cage; ten minutes later he was found dead.

Artificial respiration was not applied to any of the seven rats that were injured with alternating current. All breathed spontaneously and 86 per cent recovered completely. They were all active and lively within a few minutes following the shock. One, or 14 per cent, died, and it is believed that his life could have been saved had artificial respiration been applied at the proper time. Following the d-c. shock, five of the animals breathed at once. Artificial respiration was applied in but two cases, (29 per cent) and these animals died after a few attempts at breathing. The other five (71 per cent) recovered and in a few minutes became very active.

These tests demonstrate clearly the fact that when none of the vital organs lie directly in the path of body current the electrical injury usually is small.

ELECTRODES ON ONE FORE LEG AND ONE HIND LEG

Effects produced by the flow of current from the right fore leg to the left hind leg were studied in eight rats, from the left fore leg to the left hind leg in eight other rats, and in a third group of eight the electrodes were on the left fore leg and the right hind leg. Half of these were subjected to an a-c. circuit and the remainder to a d-c. circuit.

Not a single rat was permanently saved after contact with the d-c. circuit; one was resuscitated but only to die two and a half hours later. In several cases no heart action could be detected and at most, many of the animals gave only a few gasps. There was greater success in saving those that had been injured with alternating current, where in five cases breathing was established by a long application of artificial respiration. One of this five was paralyzed, but all including the paralyzed one became quite active soon after the shock.

Results for the 24 cases where the current path was from fore to hind leg, may be summarized as follows:

1. Artificial respiration was applied in every instance, both for the a-c. and d-c. contacts.

2. With alternating current 33 per cent of the animals recovered, eight per cent were paralyzed, and 59 per cent died.

3. With continuous current 100 per cent of the animals died.

4. Of the four subjects which recovered, the average weight was 116 grams and the average body current 0.910 ampere.

5. The rat that was paralyzed weighed 143 grams and the current that flowed was 1.060 amperes.

6. Of the nineteen subjects which succumbed, the average weight was 132 grams and the average body current 1.211 amperes.

Normally one would expect that there would be little if any difference between the effects produced by a current flowing from either fore leg to tail or by one flowing from either fore leg to either hind leg; yet in the group where the current path was from fore leg to tail, 44 per cent of the rats recovered; in the second group where one electrode was attached to a hind leg instead of the tail, only 16 per cent were saved.

Wherein, then, lies the deadliness of this current path from fore leg to hind leg? The authors believe that the high death rate found here is caused by the low-resistance path that the animal offers to a current flow when its tail is eliminated from the circuit. The average resistance of the current paths from fore legs to hind legs for the 24 rats was less than 70 per cent of that found for the 48 rats where the current paths were from either fore leg to tail. The higher resulting current is believed to be responsible for the deaths of the animals. A second argument supporting this conclusion is the almost complete absence of serious injury to the rats when the current passed from one hind leg to the other, even though the current values were high.

Discussion and Conclusions

These experiments confirm Urquhart's[4] conclusion that when an electric current passes through the brain a temporary physiological block is produced in the respiratory center and that spontaneous breathing ceases for a time. He stated that if no serious injury to the heart occurs, adequate artificial respiration may give time for the center in the medulla to recover and for normal breathing to begin. Maclachlan[3] reports in his field notes a case of recovery from shock following eight hours of continuous application of the Schaefer prone-pressure method, which also confirms Urquhart's findings. Urquhart[5], in a second series of experiments, demonstrated that a temporary block could be produced in the spinal cord or in a nerve trunk by the passage of an electric current.

Langworthy[2] found by his microscopic examination of sections of the brains of the rats injured by high-voltage electric currents that in many cases the damage to the cells was incompatible with life. Microscopic study of the central nervous systems of all of the rats in this present series will be made.

Results obtained clearly demonstrate the presence in many of the rats of a temporary respiratory block, the location of which, whether in the brain stem or in the vagus nerves, depends upon the current path. Resuscitation is possible provided the damage done does not require a recovery time too long to permit life to be supported in the interval.

Effects produced by the various current paths through the animals are summed up in Table I. From that table and from the results presented, the following conclusions may be drawn:

1. A 1,000-volt continuous-current circuit is more dangerous to rats than an alternating circuit of the same effective voltage, irrespective of the current path.

2. The chances of recovery are best when the brain does not lie directly in the pathway of the current.

3. The injury produced by the current path from the left fore leg to the tail is less severe than that caused by the same current flowing from right fore leg to tail.

4. When the main pathway of the current did not include the brain, spinal cord, or nerves required for respiration, most of the animals breathed at once and were active a few minutes after the injury.

5. The presence of a respiratory block has been demonstrated, and the fact that when natural breathing is first established the animal is not necessarily on the road to complete recovery.

6. The respiratory block is less severe, if not absent, when the current traverses the posterior portion of the body.

7. Burning of the tissues with continuous current is much more severe than occurs for the same effective alternating current.

TABLE I—SUMMARY OF RESULTS OBTAINED IN EXPERIMENTS
Submitting 161 Rats to Contact with 1,000-Volt Circuits for Two-Second Shock Periods

Current	Position of electrodes		Number shocked	Per cent requiring artificial respiration	Per cent immediate recovery	Per cent paralyzed	Per cent immediate death
Alternating	Head	Tail	16	88	31	38	31
Continuous			3	100	0	0	100
Alternating	Right fore leg	Tail	12	58	33	25	42
Continuous			12	50	42	33	25
Alternating	Left fore leg	Tail	12	75	58	17	25
Continuous			12	58	42	33	25
Alternating	Either fore leg	Tail	24	67	46	21	33
Continuous			24	54	42	33	25
Alternating	Right fore leg	Left fore leg	4	100	0	0	100
Continuous			4	100	0	0	100
Alternating	Right hind leg	Left hind leg	7	0	86	0	14
Continuous			7	29	71	0	29
Alternating	Either fore leg	Either hind leg	12	100	33	8	59
Continuous			12	100	0	0	100

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Electric Power in the Steel Industry

A brief outline of some of the revolutions in production methods brought about by electrification on a large scale.

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SINCE the World War practically every industry has been subject to a declining market price of its commodity. The very definite problem before industry during this post-war period has been to modify production methods and processes in a manner which will permit the manufacture of commodities at a constantly declining cost.

Perhaps in no industry has there been greater progress in recent years than in the steel industry and some of the major advances that are attributable to the application of electricity, not only to auxiliary drives and annealing processes but also to the replacement of the large steam engines for main roll drive with motors, far exceed in performance and output anything obtainable by steam. Perhaps even more vital than the application of motors to main rolls has been the installation of delicate and accurate control devices which has brought about a complete change in the rolling of steel.

Up to 1921 the steel industry had been accepting electrification but not in the wholehearted manner as it now does. As to main rolling drive, there was considerable argument between the steam advocates and those who were in favor of electric drive; but when the steel industry was definitely confronted with a steady decline in the price of steel products the curtain was drawn abruptly on further debate and many large engines were replaced by electric drives. At that time an electrified plant enjoyed an advantage of $2.50 per ton of product over a steam-driven plant; at present this difference is even greater.

One of the first products to feel the far reaching effects of electrification was strip formerly rolled in mills where the metal was passed back and forth by hand from one stand to another. The drawback in this type of mill was not only that it required a great amount of hard labor but that the thin metal traveling along the cold floor would lose its temperature rapidly. The tandem motor-driven mill arrangement not only reduced the amount of power required to roll the steel but enabled the same slab to be finished to a thinner gage.

So long as steam engines were used this newer type of tandem mill of course was impossible because it is necessary to have, for the driving of each stand, individual units which can be adjusted in speed to accommodate different drafts in individual stands and maintain a pre-set speed whether the load be light or heavy.

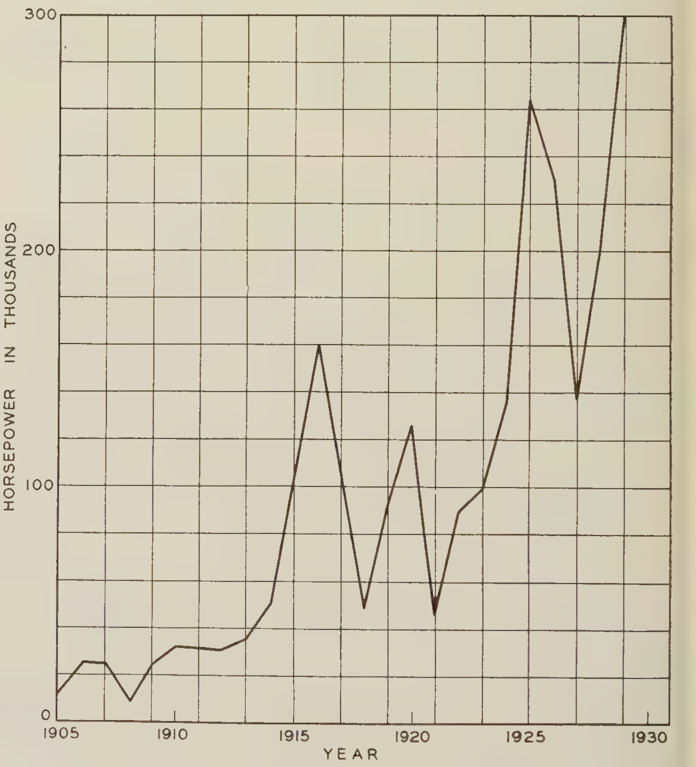

Fig. 1. Installed horsepower on main-roll mill drives is increasing rapidly

Strip usually covers a range from 3 to 20 inches in width while sheet varies in width from 30 to 60 inches. Since the continuous type of individual motor-driven mills proved so successful in strip mills it is only natural that present day production of heavy sheets is being drastically changed. The transition has not reached

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From "The Use of Electricity in the Steel Industry," presented at the Western Metals Congress, San Francisco, Feb. 16-21, 1931.

that same conclusive state as it has in strip mills and at the present time only the heavier sheets are being rolled on this type of mill. It is possible however that in the near future continuous rolling of sheet will be almost as complete as the continuous production of strip.

From sheet to plate is the next logical step; consequently the first installation of a continuous plate mill is being made now. In other words the use of the tandem-mill motor specially designed for flat speed regulation has gone from strip to sheet mills and now is invading the plate-mill field. In general, the old type of mill was able to produce from 10,000 to 15,000 tons per month.

Recently with the development of structural shapes has come a new type of wide-flange mill where motor drive has been utilized. In the rolling of these larger and relatively more complicated shapes only the advent of sensitive, sturdy, and accurate automatic electrical control devices has made the wide-flange mill an operating success. In one mill typical of this a 7,000-hp. motor drives the main rolls (used on the web and inside flanges of a beam) and also two vertical rolls which reduce the outsides of the flanges. Adjacent in the line of production is a set of auxiliary horizontal rolls which reduce the edges of the flanges. These auxiliary rolls are driven by a 2,000-hp. motor. It is essential that these two motors remain in synchronism regardless of the relative load on either of them. Also, with the material passing back and forth between these three sets of rolls and with the different drafts to be taken on the rolls, various speed relations between the three sets of rolls must be pre-set and rigidly maintained for any given pass. This represented one of the difficult problems in the design of the electrical equipment for this mill. It not only required a careful designing of the control but of the motor as well.

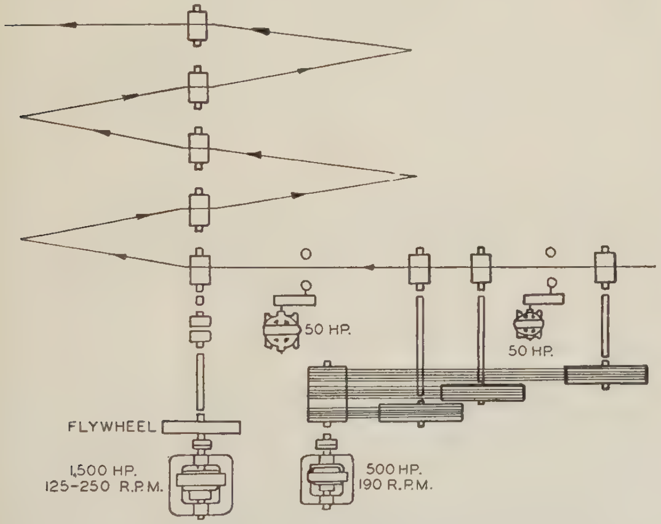

Fig. 2. Layout of typical older type of 14-in. strip mill showing hand transfer between finishing stands. Compare with Fig. 3

The other problem was to establish a proper setting for the three sets of rolls as the metal was being reduced from a beam blank to a finished beam. It may be imagined that if heavy drafts were taken in the vertical rolls during the early passes, while most of the work to be done by the main horizontal rolls was delayed to the last few finishing passes, there would be considerable distortion and unnecessary strain set up in the metal. With three sets of rolls to be adjusted after each pass it was inconceivable that two men would reproduce properly the drafts as each piece of metal came through the mill, a matter of importance in securing uniform elongation of the metal throughout its entire section; further, unless drafts could be predetermined it would be impossible to pre-set the speed of the 2,000-hp. motor. For this reason arrangements were made to operate the screwdown on the three sets of rolls automatically for each individual pass and at the same time adjust the field of the 2,000-hp. motor for its correct speed. This automatic setting of the rolls for each individual pass was the second distinct contribution made to the phenomenal success of this type of mill by electrification.

FUTURE PROSPECTS

There are many other instances where the steel industry has utilized electrification to maintain a prosperous condition regardless of the decline in the price of steel. Probably one of the most spectacular changes from a labor point of view is in the production of wrought iron. At the present time one company is incorporating a method of manufacturing wrought iron by merely pouring the molten iron from one ladle into another containing molten slag. In three minutes a three-ton ingot is produced by a few men, whereas by the old method it took twenty men two hours. The old method of puddling might be termed a back-breaking job meant for young men only; today the seasoned man of fifty with steady habits is better adapted to manipulate the machinery required for this new process.

There is no question but that still further changes of great consequence to steel production will be obtained through the use of electricity. As yet there is little appreciation of the full use to which electricity may be placed, but these possibilities will be unfolded in the future just as they have been in the past.

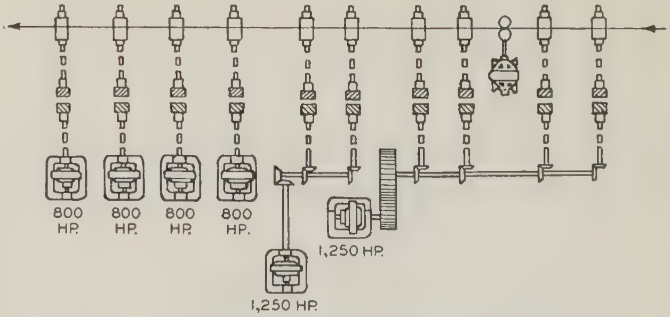

Fig. 3. Layout of modern 14-in. strip mill. Compare with Fig. 2

A Neutralized Welding Generator

By reducing the magnetic energy stored in the generator field, transient currents in d-c. welding machines can largely be eliminated. Providing such generators with neutralizing windings reduces this energy to a minimum.

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ARC-WELDING generators of the d-c. type in order to be satisfactory not only must operate at constant current over a wide range of voltages, but must also be free from heavy transients. The operation of such machines can be improved vastly by incorporating in their design a winding to neutralize the effect of armature reaction in the generator, and a high external reactance in series with the arc.

It should be noted at the outset that two different types of welder are possible—the separately-excited type and the shunt type. The former type has a separately-excited coil in its field, its ampere-turns opposed by a coil connected in series with the armature; the shunt type, in addition to this, has a shunt coil on the field.

It is proposed that in the case of a shunt type of welder its shunt coil and separately-excited coil should be combined into one in the manner shown in Fig. 1. If to a shunt coil and a separately-excited coil, each of resistance R, are applied voltages E_1 and E_3 respectively, the currents in each will clearly be E_1/R and E_3/R. If instead of this a single coil is used, still of resistance R, and is submitted to an e. m. f. equal to $E_1 + E_3$, then the current will be $E_1/R + E_3 R$; that is, the ampere-turns will be just the same as in the case of the two separate coils. This construction provides a minor simplification in the design of this particular type of machine. Its chief advantages, however, are that by rendering leakage between the shunt and separately-excited windings impossible (since they are now the same winding), it reduces transient currents and prevents damping of the shunt currents by the separately-excited winding.

In any study of welder design, a careful consideration of transient characteristics is of the utmost importance. Although the steady characteristics of a welder may show a constant current for a wide range of voltage, if transient variations from these conditions are possible, the machine still will be unsatisfactory.

If the current is capable of a sudden jump from one value to a higher one, then any sudden shortening of the arc or contact with the work means that an excessive amount of energy is suddenly concentrated in it, resulting in an explosion with the familiar "spluttering" so annoying to welders. This spluttering is almost entirely the fault of the generator.

It will be clear now that the steady characteristic of the generator (for instance as measured on a resistance load), does not indicate whether it is good or bad for welding purposes. It must have an additional quality which is vaguely called stability; which brings up the question as to how this stability may be calculated and measured?

It is proposed that the stability of all welding apparatus be defined in terms of what may be called the "stability ratio," and that the stability ratio be defined and measured by (1) applying full load to the welder by means of a resistance, as for example, 200 amperes at 30 volts; (2) by arranging a switch so that the resistance may be short-circuited instantly thereby instantly short-circuiting the terminals of the machine through the steadying reactance; and (3) by measuring the maximum current kick produced (600 amperes for example) when the short-circuiting switch is closed. The stability ratio is then the ratio of this maximum kick to the normal full-load current.

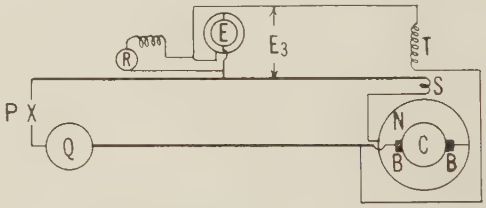

Fig. 1. Schematic diagram for neutralized welder

The shunt and separately-excited fields have been combined in a single winding *T*. The neutralizing winding is designated at *N* while *Q* represents the arc series reactance

In the example given, where the kick is 600 amperes and the full-load current 200 amperes, the stability ratio is 3. Under a small stability ratio the welder will operate steadily.

There is no serious difficulty in measuring this kick by well-known methods with instruments ordinarily found in a test room: First the glass front is removed from an ammeter, preferably one of the moving-coil or dynamometer type whose moving system has a low moment of inertia. By means of a pencil point, or otherwise, the needle is held at approximately the value

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From "The Neutralized Welder—A Means of Controlling Transients," (**No. 31-31**), Presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

which the current is expected to have—say 600 amperes. Next, the machine is short-circuited, and if the current is less than the value indicated by the pointer, it will continue to rest against the pencil point and be prevented from moving back to zero. If the current is greater, the needle will momentarily flutter away from it to a greater or less extent. If, however, there is no flutter, the test should be repeated with the needle held opposite a lower reading on the scale, say 500 amperes. If the flutter is vigorous, the needle should be held opposite a higher reading on the scale, for instance 700 amperes—the test being repeated until a point is found where the needle shows only a slight indication of movement. By this means, using only standard d-c. instruments, the instantaneous short-circuit current may be measured with fair accuracy.

It is necessary that the voltage of the generator be able to respond rapidly to changes in arc length while the current remains constant; it would seem therefore that the separately-excited type of generator in which no voltage variation whatever can take place unless there is current variation must be inferior to the shunt type in which voltage and current variation are independent of one another. Up to a few years ago this reasoning was common but since as hitherto designed the shunt type of machine was found to be sluggish—that is, the voltage did not rise sufficiently fast with increasing arc length—it has fallen into disrepute.

After a rather complete mathematical study of welder transients it was concluded that this sluggishness arises from the large amount of magnetic energy stored in the field system of machines of ordinary design. For instance when the voltage increases, the flux of the machine must increase also; and if this requires a large increase in magnetic energy, then a certain amount of time must elapse before that energy can flow in. The proposal outlined in the beginning provides that the magnetic energy stored in the field system be reduced to a minimum. Again if there is leakage between the series and the shunt or separately-excited coils, or to borrow a term from radio practise, they are "loosely coupled," the transient current in the separately-excited coil is not closely conditioned by current changes in the series coil.

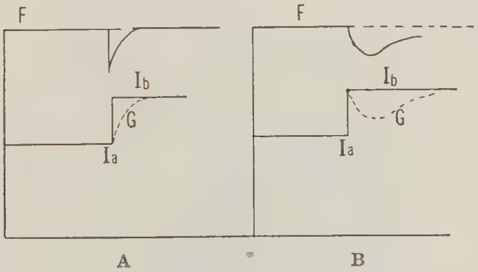

Fig. 2. Current diagrams for a generator with small field leakage (A) and high field leakage (B)

I_a and I_b represent the welding current, F the current in the separately-excited coil, and G the resultant ampere-turns

The foregoing is illustrated in Fig. 2; in the case of small leakage as shown at A, when the welding current rises from I_a to I_b, the increased ampere-turns of the series coil are instantaneously masked by equal and opposite ampere-turns in the separately-excited coil whose current is shown at F; if the energy stored in this circuit is small, these transients die away at an exceedingly rapid rate so that the flux very rapidly takes up its new value. With high leakage as shown at B, the change in the ampere-turns in the series coil immediately influences the flux, since the transient currents in the separately-excited coil have considerable lag. Later the transient current in the separately-excited coil starts causing the flux to return to nearly its original value after which the transient gradually dies away, the net effect being that the flux first falls, then increases, and then gradually falls again—a very undesirable condition. Hence, one may summarize the condition which leads to good transient characteristics in a welder by stating that there should be "close coupling" between the series and shunt or separately-excited coils. It has been shown that under this condition both the magnetic energy and the leakage should be small.

In Fig. 3 are shown oscillograms of welding current for a welder whose field windings are separate and those for a welder arranged as shown in Fig. 1. By comparison of these two curves it is obvious that the initial rise of current which is universal in welders whose transient characteristics have not been carefully studied, is entirely absent in welders designed as previously outlined. It is evident that in the latter case there is no sudden concentration of energy when the electrode touches the work.

Results of a thorough, mathematical study of the problems involved are briefly summarized in the following paragraphs.

In the welding generator, two distinct problems exist:

1. The current must be held constant during rapid changes of conditions. This is solved by the use of reactance.

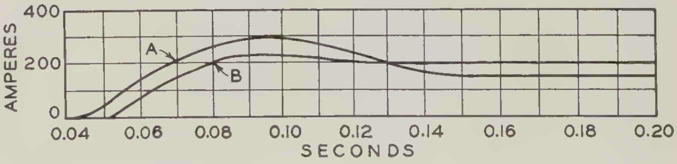

Fig. 3. Current-time relations in a neutralized welder suddenly subjected to full load. (A) Shunt and separately-excited fields independent; (B) a single winding used for both

2. The machine must be so designed that the voltage generated may vary rapidly to meet changes of conditions without much change of current.

It is essential to recognize that there are two distinct problems and not one, and that only the second of these requires the use of a special generator. Every change in voltage involves a change in field strength, and in connection with this the following requirements should be noted:

1. Rapid changes require that field variations must take place with only a small inflow or outflow of magnetic energy to the field; or in other words, *the magnetic energy stored in the field shall be as small as possible.* For this purpose the generator should be designed with: (a) low saturation, (which will be secured in any case, owing to the need for a high voltage on open circuit); and (b) the shortest possible air-gap involving semi-closed rotor slots and laminated pole tips.

2. Low magnetic energy means very rapid increment or decrement of flux to meet changed conditions; and also the absence of oscillations where a large external self-inductance is used.

3. Oscillations are due primarily to the fact that the magnetic energy stored in the field is about equal to that in the reactance. This condition should be avoided; the energy stored in the reactance should be much greater than that stored in the field.

4. To store a large amount of energy, the reactance should have many turns, and a fairly long air-gap. (It may be made of cast iron, or cast steel.)

5. It is common practise to use for this purpose the reactance of the armature circuit due to the cross-flux. This is bad practise because: (a) The necessity for a short air-gap has just been pointed out in the interests of low stored field energy. (b) If there are many armature turns with a short air-gap, the cross-flux will produce high saturation, tending to increase the stored field energy. (c) If the pole arc is wide this cross-flux will create sparking. (d) If we reduce the pole arc to avoid this, we reduce the reactance formed by the cross-flux and increase the reluctance of the field. (e) A concentrated interpole winding diminishes the effectiveness of the machine as a reactance.

6. Because of this, it is better to use a *neutralizing winding* or distributed interpole, completely abolishing the cross-flux, and to have the reactance in separate form. The endeavor to combine the conditions for maximum reactance and the opposite conditions for minimum field energy mean that neither set of conditions can be met satisfactorily; only separate pieces of apparatus can satisfy both in the best possible manner.

7. Even with a purely separately-excited machine this is true. If there is a shunt coil in addition, the placing of the reactance external to the tapping points of the shunt circuit has the further advantage of shielding the shunt winding from the rapid oscillations of the arc.

8. Owing to lag caused by the self-induction of the main field, connecting the shunt winding directly across the arc does not enable it to follow rapid variations, although it can follow fairly slow ones. It is therefore better to rely upon the reactance to deal with rapid variations, and shield the shunt winding from them.

9. The lower the field energy and the higher the field resistance, the more rapid are the variations which can be followed.

10. The higher field resistance also tends to check oscillations but more power is required for excitation, and in a machine with a shunt circuit it is desirable that the field resistance be such as will give the constant-current condition. It seems better therefore to rely on other means; namely, low field energy, and high external reactance to avoid oscillations, and *not* connecting the shunt circuit directly across the arc. This last is perhaps a point of secondary importance, and one to which some difference of opinion might be allowed.

11. Leakage self-induction in the shunt or separately-excited circuit prevents rapid response by permitting the shunt current to vary at a different rate from the armature current. Such leakage is the *sole* cause of these variations.

12. If there is no leakage between the series coil and the shunt or separately-excited coil, all currents must vary at exactly the same rate making "sluggishness" impossible.

Welders designed in this way may be built conveniently with slotted stators, although this is not necessary. This construction renders it possible to reduce greatly the cost of a welding set by combining the welding generator itself with an induction motor in the same magnetic structure. It can be accomplished as shown in Fig. 4. The two machines are arranged for different pole numbers, circuits belonging to the welding generator being at the back of the slots while those of the induction motor are at the front. The rotor has an ordinary d-c. winding suitable for the welding generator and fitted with equalizers. Through these equalizers the secondary currents of the induction motor flow, and in this way are prevented from appearing at the commutator at all. An illustration of the complete apparatus as built with vertical shaft is given in Fig. 5.

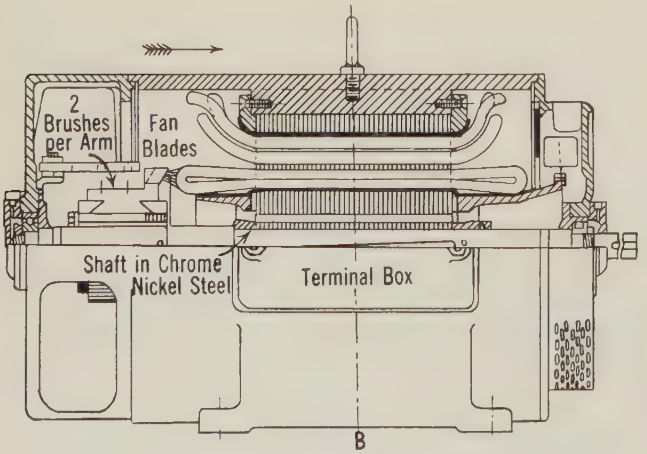

Fig. 4. Combined welding generator and induction motor with slotted stator

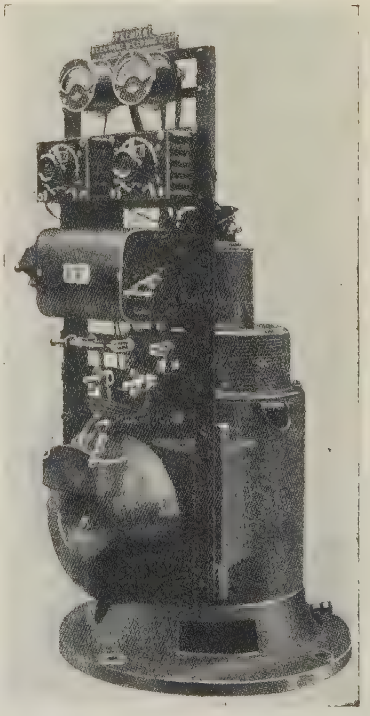

Fig. 5. Complete neutralized d-c. welding set built with vertical shaft

Some Effects of Unbalanced Faults

By
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Line-to-ground voltage in three-phase grounded-neutral electric power systems under fault conditions often may be greater than the line-to-line voltage. This and numerous other important relations are shown by an investigation of the wide range of power-system voltages and currents existing under fault conditions.

SINCE THE INTRODUCTION of the method of symmetrical components as a powerful tool for the solution of electric-circuit problems, it has been used in many system analyses. Utilizing symmetrical components, this article shows by means of curves and tables the full range of fundamental-frequency voltages and currents obtained in a three-phase system under various fault conditions; it discusses also certain phases of application such as grounding and circuit-breaker duty, and points out the not generally appreciated existence of certain abnormal values in typical systems.

In terms of symmetrical components any symmetrical system is defined and described fully by the generator voltages and the positive-, negative-, and zero-sequence impedances. Thus, Fig. 1 shows the equivalent diagrams of a system for three-phase, line-to-line, single-line-to-ground, and double-line-to-ground short circuits. Since the system is symmetrical, identical values of voltage and current are obtained for any one type of short circuit regardless of which particular phases are faulted; details of the analytical work are simplified for any one type of short circuit, however, if the reference phase (phase a) is the one which is open when the other two phases are faulted, and vice versa. Fig. 2 shows the sequence network connections from which the components of current and voltage of phase a are computed; and from these latter, in turn, the components for phases b and c are obtained readily. Because of the large number of possible variables it is desirable before drawing up curves illustrating the ranges of voltages and currents to make certain common assumptions and simplifications. For instance, it is assumed that the system is short-circuited from no-load and internal generator voltages equal and in phase; that the system is without shunt capacitance; and that short-circuit currents are limited only by (inductive) reactance except in the ground-current path, where resistance also is considered. For the sake of generality the sequence impedances are expressed as ratios to the positive-sequence reactance, the latter being that which determines the three-phase short-circuit current; currents are expressed as ratios to the three-phase short-circuit current, a convenient reference quantity; voltages, both line-to-ground and line-to-line, are expressed as ratios to their respective *normal* values. Thus for a given system the curves may be used by computing the ratios of sequence impedances.

TABLE I—LIST OF SYMBOLS
(See Illustrations)

a, b, c = the three phases of a three-phase system in which normal phase sequence is a, b, c.
E_a, E_b, E_c = line-to-ground voltages at point of fault.
E_{ab}, E_{bc}, E_{ca} = line-to-line voltages at point of fault.
E_G = generated positive-sequence voltage of phase a, at the source; when several machines are involved, this becomes an equivalent generated voltage. (*Studies of Transmission Stability*, by R. D. Evans and C. F. Wagner, A. I. E. E. TRANS., 1926, Vol. XLV, pp. 73 and 79.)
E_1 = positive-sequence voltage at point of fault.
I_a, I_b, I_c = line currents at point of fault.
I_g = ground current at point of fault. ($= 3\ I_0$)
I_0 = zero-sequence current at point of fault.
R = fault resistance.
R_g = fault resistance affecting directly the flow of ground current of a double-line-to-ground fault.
R_L = fault resistance in each of the faulted phases of a double-line-to-ground fault.
R_0 = zero-sequence resistance (per phase).
R_1 = positive-sequence resistance (per phase).
R_2 = negative-sequence resistance (per phase).
X_0 = zero-sequence reactance (per phase).
X_1 = positive-sequence reactance (per phase).
X_2 = negative-sequence reactance (per phase).
Z_0 = zero-sequence impedance (per phase).
Z_1 = positive-sequence impedance (per phase).
Z_2 = negative-sequence impedance (per phase).

NOTE: All currents, voltages, and impedances listed above are scalar quantities; an inverted circumflex ($\check{E}_g$) above any symbol indicates the vector form, which may be expressed in terms of complex numbers.

The titles and legends make the curves practically self-explanatory. (A list of symbols is given in Table I.) Voltages and currents at the fault location are shown in Figs. 3 to 7 inclusive. In Fig. 3 all resistances are taken equal to zero, voltages and currents being plotted as functions of the sequence reactances. Since in a resistance-grounded system the zero-sequence resistance is an important factor in Figs. 5 and 6 this is taken as a variable. In these two illustrations only the curves for the case of positive- and negative-sequence reactances being equal ($X_1 = X_2$) are given here. Positive- and negative-sequence reactances are equal for symmetrical static networks, but rotating

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From "Power System Voltages and Currents Under Fault Conditions," (No. 31-59) presented at the Middle Eastern District meeting of the A. I. E. E., Pittsburgh, Pa., March 11-13, 1931.

machines in a system may cause these reactances to differ. Table II summarizes the ranges of voltages and currents shown in these figures.

TABLE II—RANGE OF FAULT CURRENTS AND VOLTAGES

Type of fault	Current ratio* Line	Current ratio* Ground	Voltage ratio L-G†	Voltage ratio L-L‡
L-L	0.69—1.15		0.67—1.20	0.58—1.04
L-G	0.00—2.00	0.00—2.00	0.58—1.97	0.67—1.20
$2L$-G	0.69—2.02	0.00—3.00	0.00—1.80**	0.00—1.04**
Based on	$\frac{R_1}{X_1} = \frac{R_2}{X_1} = 0$		$0 \leq \frac{R_0}{X_1} \leq \infty$	
and	$\frac{X_2}{X_1} = 0.5$ to 1.5		$0 \leq \frac{X_0}{X_1} \leq \infty$	

*Reference is the three-phase short-circuit current.
†Reference is the normal line-to-neutral voltage.
‡Reference is the normal line-to-line voltage.
**These voltages are identical; only the line-to-ground voltage curves have been plotted.

One of the most important facts brought out by these curves is that the line-to-ground voltage may rise to a value of 190 per cent of normal (somewhat greater than the normal *line-to-line* voltage), a fact not generally appreciated. It is interesting to note that the ratios of line and ground current to the three-phase short-circuit current may be as great as 1.5 and 3.0, respectively; also, that the ground current of a double-line-to-ground fault may be much greater than the maximum value of a single-line-to-ground fault. Some of these values are still greater for cases (not shown here) where the negative-sequence reactance is not equal to the positive-sequence reactance.

It is pertinent to say (as the curves show in part), that generally the maximum values of fault currents are obtained with low values of zero- and negative-sequence *reactances*; and correspondingly, that the maximum values of voltages occur with high values of zero- and negative-sequence *reactances*; for zero-sequence *resistance* (R_0), however, such is not the case; maximum values of currents and voltages are obtained mostly with intermediate values of R_0. Also it may be noted that the adding of zero-sequence resistance to a system having no resistance increases the line current on a double-line-to-ground fault; consequent increase of this resistance reduces line currents as well as ground currents, but increases line-to-ground voltages.

SYSTEM PERFORMANCE

From the foregoing it is evident that two systems of the same voltage having identical values of three-phase short-circuit current for particular fault locations may have radically different voltages and currents for *unbalanced* faults. Line currents are important because of the mechanical stresses which they set up in rotating machines, transformers, reactors, circuit breakers, and bus structures. High voltages are important because of the stresses produced by them on apparatus or line insulation, as well as on lightning arresters. In circuit-breaker and relay applications combinations of voltage and current are important. Certain applications require consideration not only of the symmetrical effective values of voltages and currents as given but of asymmetrical components, machine harmonics, and high-frequency oscillations resulting from stored energy changes. Some aspects of certain general system problems will be discussed briefly:

The general classification of systems with respect to grounding is (1) ungrounded, (2) grounded through

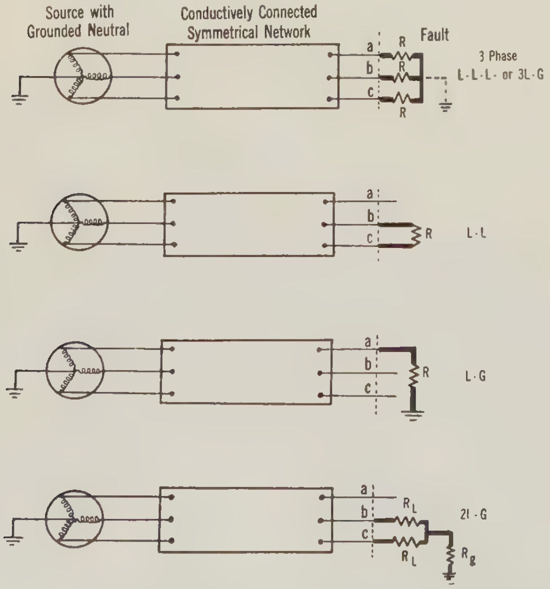
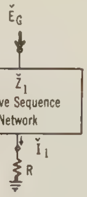
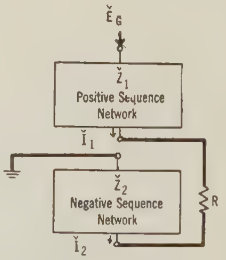

Source with Grounded Neutral
Conductively Connected Symmetrical Network
Fault
a
b
c
R
R
R
3 Phase L-L-L- or 3L-G
a
b
c
R
L-L
a
b
c
R
L-G
a
b
c
R_L
R_L
R_g
2L-G

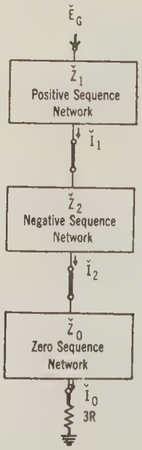
Fig. 1. Types of faults on three-phase systems

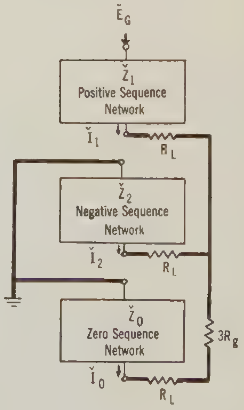


(a) Three-Phase Fault (L-L-L or 3L-G)



(b) Line-to-Line Fault (L-L)





(c) Single Line-to-Ground Fault (L-G)

(d) Double Line-to-Ground Fault (2L-G)

Fig. 2. Equivalent networks for four types of faults on three-phase power systems

mpedance (resistor or reactor), and (3) free neutral. (For the purpose of this classification, a system grounded through neutral eactance resonating with line capacitance may be viewed as a free-neutral ystem, since the object of the reactance is to nullify line capacitance; in his paper the phenomena of arcing grounds is not treated, and in general he grounding impedances are assumed to be so low that arcing grounds re avoided.)

t is a fact, however, that actually the zero-sequence mpedance of a direct-grounded system may be higher han that of a system of similar capacity and extent vhich is grounded through a neutral impedance of low value. Obviously, the classification given is unsatisfactory since it takes into account only the impedance between ground and neutral points of certain pieces of apparatus, instead of the total effective zero-sequence impedance which includes line and apparatus mpedance as well as that of grounding resistors and eactors.

A much more accurate classification of systems with espect to grounding is suggested by Figs. 3 to 6. The curves as given cover the full range of system grounding rom a direct-grounded system to a free-neutral system, and suggest that *the ratio of zero-sequence impedance o positive-sequence reactance be used as a criterion or measure of the "degree of grounding,"* low values of this ratio corresponding to a solidly-grounded system and high values to a free-neutral system. Hence, the criterion is not one by which to determine whether there is an impedance between one or more neutral points and ground but, more accurately, whether the ratio of zero-sequence reactance or resistance to positive-sequence reactance is high or low. For convenience this ratio is called the "zero sequence impedance ratio."

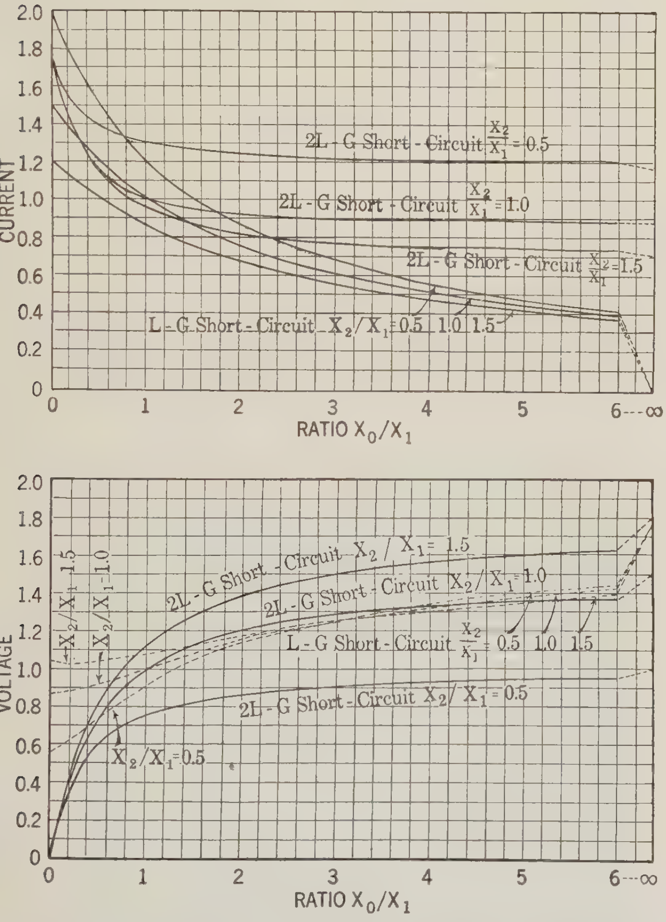


Fig. 3. (Above) fault currents vs. system reactances and (below) fault voltages vs. system reactances for single- and double-line-to-ground faults

Currents (above) are expressed as a ratio to the three-phase short-circuit current. Voltages (below) are line-to-ground values and are expressed as ratios to the normal line-to-neutral voltages. $R_1 = R_2 = R_0 = 0$ in all cases

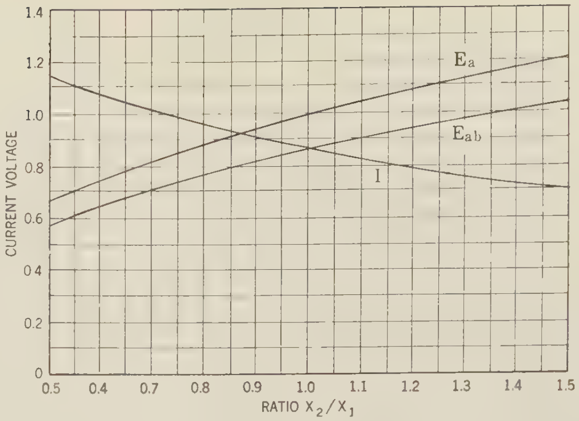


Fig. 4. Fault current and voltages vs. system reactance for line-to-line fault

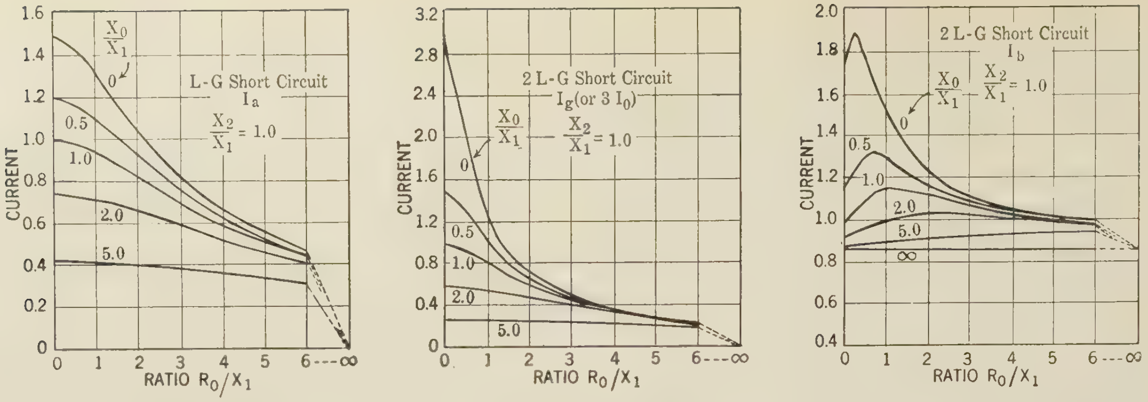
Current is expressed as a ratio to the three-phase short-circir-circuit current; voltages are expressed as ratios to their respective normal values

Various methods of grounding a system have rather complicated effects on stability limits. Decrease in positive-sequence voltage may cause an underexcited and overloaded synchronous machine to pull out of step without causing the system as a whole to lose synchronism. At various times it has been suggested that the positive-sequence voltage at the fault location is a measure of the stability of a system under fault conditions. Accordingly, Fig. 7 has been plotted to show the range of this voltage for single- and double-line-to-ground faults respectively. Voltage is plotted as a ratio to the normal line-to-neutral voltage, and impedances are expressed as ratios to the positive-sequence reactance.

CIRCUIT-BREAKER OPERATION

The effective current flowing through a pole of the breaker before it opens, and the effective voltage occurring across that pole after opening are used often as a measure of the duty imposed in opening a short circuit. It should be clearly realized that this measure does not take all factors into account. Dr. Joseph Slepian has pointed out that the most significant factor is the rate of restoration of voltage at the instant at which the current passes through zero.

The phenomenon of arc extinction has been likened to a race between the build-up of voltage, and the deionization of particles in what was the arc stream before the arc was extinguished. Recovery voltages are affected by the presence of asymmetrical currents,



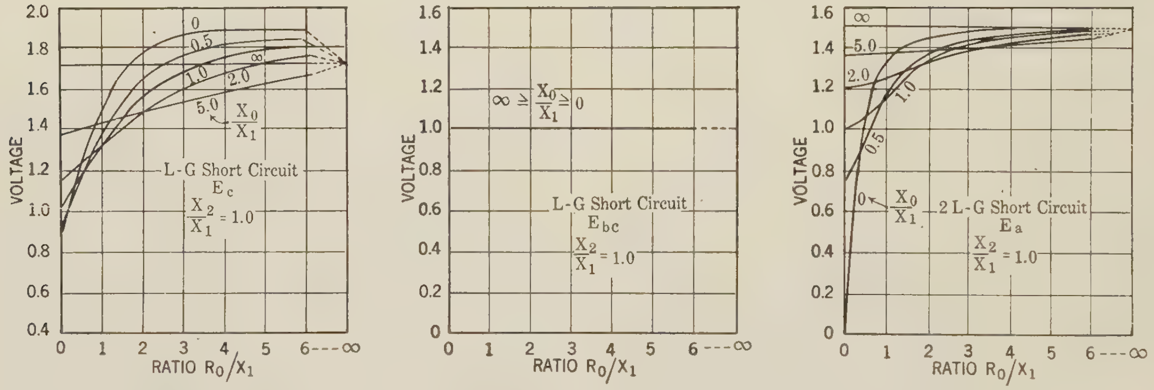
Line current for single-line-to-ground fault

Ground current for double-line-to-ground fault

Line current for double-line-to-ground fault

Fig. 5. Fault currents vs. system impedances for different types of faults

Curves in each group are for various values of the ratio X_0/X_1. All currents are expressed as a ratio to the three-phase short-circuit current



Line-to-ground voltage for single-line-to-ground fault

Line-to-line voltage for single-line-to-ground fault

Line-to-ground voltage for double-line-to-ground fault

Fig. 6. Fault voltages vs. system impedances for different types of faults

Curves in each group are for various values of the ratio X_0/X_1. All voltages are expressed as ratios to their respective normal values

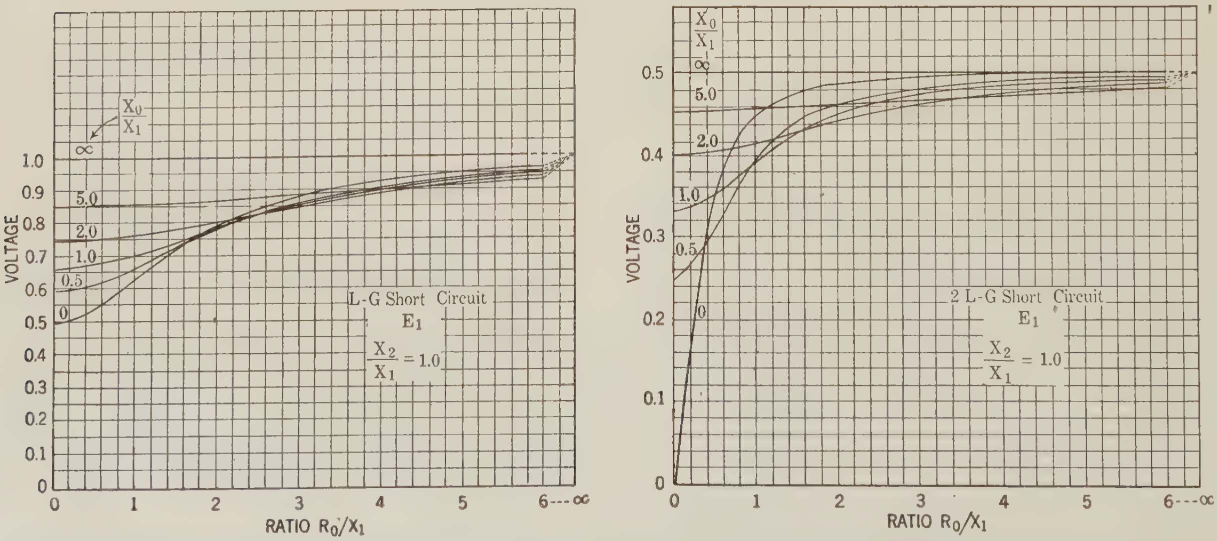


Fig. 7. Positive-sequence voltages at the fault vs. system impedances for (left) single-line-to-ground and (right) double-line-to-ground faults

Curves in each group are for various values of the ratio X_0/X_1. All voltages are expressed as ratios to the normal line-to-neutral voltage machine harmonics, and high-frequency oscillations, but any of these may either increase or decrease the rate of restoration of voltage; hence, it probably is true in comparing two similar systems of the same voltage and equal three-phase short-circuit current that the system with the highest effective recovery voltage for fault conditions will have the highest rate of change of voltage at the critical point of the wave. Regardless of whether the product of the effective current before the pole opening and the effective voltage after the pole opening may be taken as a measure of breaker duty, this product appears to be suitable as a measure of the influence of the sequence impedances on circuit breaker duty.

For the various steps possible in the clearing of the different types of faults the aforementioned product has been computed and plotted in Fig. 8. This product is obtained from the curves of Fig. 3. For example, with a three-phase grounded short circuit, the opening of the first pole changes the fault from a three-phase to a double-line-to-ground fault and the product is of the three-phase short-circuit current and the voltage of the double-line-to-ground fault. The ordinate of Fig. 8 is the ratio of the product of voltage and current for a particular pole to the corresponding product of the three-phase short-circuit current and the normal line-to-neutral voltage; the abscissa is the ratio of zero-sequence to positive-sequence reactance. For the sake of simplicity all resistances have been assumed as zero and curves are shown only for the case of positive- and negative-sequence reactances being equal.

The curves of Fig. 8 indicate that under some conditions any tendency for one pole to open before the others becomes augmented as a result of the increased duty imposed on the last poles to open (regardless of the fact that the breaker may be in proper adjustment). This may be compared to a state of unstable equilibrium. The following points are salient: (1) when zero-, positive-, and negative-sequence reactances are equal the circuit breaker kva. per pole is independent of the type of fault or the sequence of opening; (2) for any other ratio of zero-sequence to positive-sequence reactance the maximum kva. per pole is increased for some one step in the sequential opening of a breaker on a three-phase fault. Thus there may be a wide range of values of the kva. per pole when clearing faults, depending upon the type of fault, sequence of pole opening, and the sequence impedance ratios.

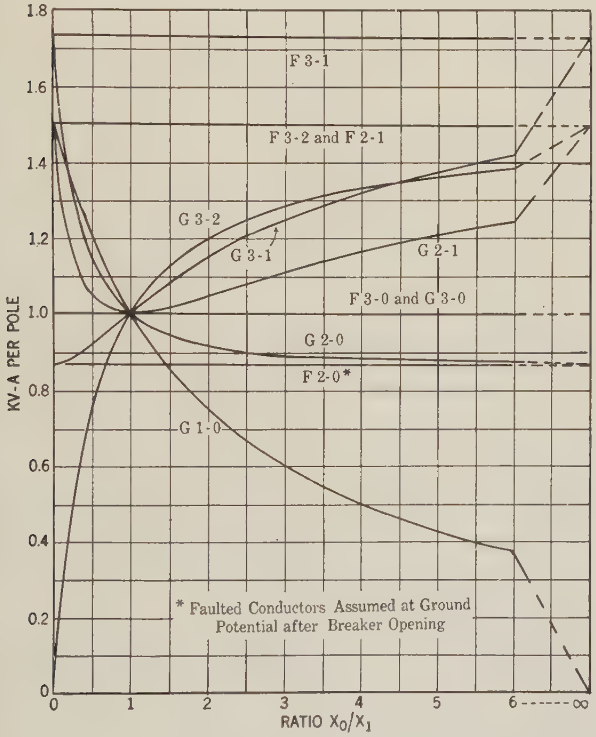


Fig. 8. Circuit-breaker kva. vs. sequence reactances for $X_1 = X_2$

Each curve shows the kva. for a pole the opening of which is one particular step in clearing a fault; curve labeling indicates number of poles closed both before and after this opening, and whether fault is grounded or free from ground (*G* or *F*). Ordinates are ratios of the product of the symmetrical r. m. s. current through a pole before opening and the voltage after opening, to the product of the three-phase short-circuit current and the normal line-to-neutral voltage. All resistances are taken equal to zero

COMPARISON OF GROUNDING METHODS

The previous analysis shows definitely that the fault voltages or currents may be taken as factors indicative

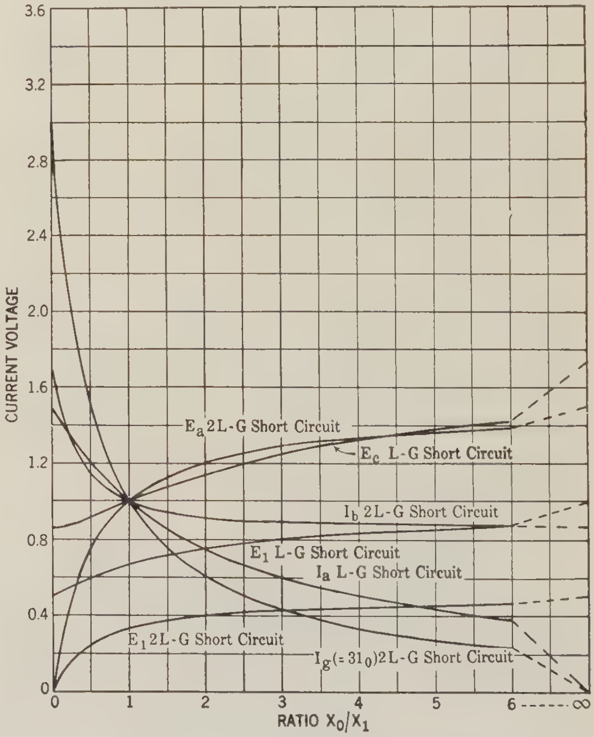


Fig. 9. Typical curves for system grounding study. Fault currents and voltages vs. zero-sequence reactance ratio for system in which $X_1 = X_2$ and all resistances are negligible

Ordinates are fault currents and voltages; currents are expressed as ratios to the three-phase short-circuit current; voltages as ratios to the normal line-to-neutral voltage. These curves were derived directly from Figs. 3, 4, 5, 6, and 7 of certain aspects of system performance, and that they are determined mainly by the value of the zero-sequence impedance ratio. Obviously a preferred value of this ratio depends upon the weight given to the various factors and upon the particular system involved. Fig. 9 illustrates the use and value of the foregoing analysis as applied in a study of system grounding. It is important to note that (1) as the ratio of zero-sequence to positive-sequence reactance varies from 0 to 1, the disadvantages decrease and the advantages increase while, (2) as this ratio goes above 4 there is relatively little of either gain or loss. Hence, the *preferred range of the zero sequence impedance ratio appears to be from 1 to 4.*

Fundamental Basis for Distance Relaying

For single-line protection, with the exception of pilot-wire, or superposed high-frequency methods, distance relays form the nearest approach to the theoretically ideal system. Except for errors due to fault resistance, these relays operate accurately according to the relative distance to faults.

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AN IDEAL SYSTEM of relays for the protection of a sectionalized transmission line is one capable of dividing into two classes all faults on the lines it protects; in one, those faults occurring between the relay and the next sectionalizing point; and in the other, all other faults. It should also be capable of making this classification instantaneously. If a fault falls into the first class, the circuit breaker may be tripped immediately, thus reducing damage at point of fault and shock to the system; in general, permitting operation nearer the stability limit. If the fault falls in the second class, the circuit breaker would not be tripped or tripped only after a time delay which is great in comparison with the time required for breaker operation.

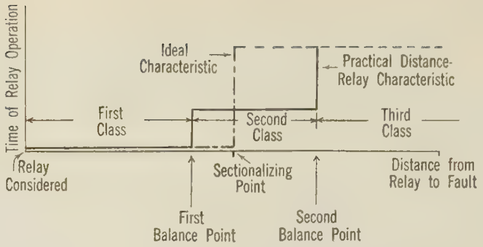

Fig. 1. Ideal and practical characteristics for distance-relaying systems

Exclusive of pilot wire or superposed high-frequency methods, the closest approach to this ideal for single line protection is attained by the use of distance relays. For parallel-line protection a somewhat closer approach to the ideal has been obtained by balanced-current relays; but additional protection is required for single-line operation and to care for the possibility of simultaneous faults on both lines, for this distance relays are well suited. Hence, if the distance relays can be made sufficiently accurate and rapid, the use of the balanced-current relays is non-essential.

Since distance relays cannot indicate with 100 per cent accuracy the distance to the fault, an additional intermediate class of faults must be introduced (see Fig. 1) comprising those which occur near the end of the section on both sides of the sectionalizing point. If a fault falls into the intermediate class, there is introduced a time delay sufficient to allow a breaker at the next sectionalizing point to trip in response to its relays which operate instantaneously; if the fault is just beyond the next sectionalizing point, it will fall into the first class of faults for the relays located at that point, and the fault will be cleared by the opening of the breaker at that point, allowing the first relay to reset; if the fault is just within the section, the relay at the original station will operate at the expiration of the time delay. Thus the final classification of faults falling in the intermediate class is made with the assistance of other breakers and relays.

In order to strike the boundaries of the intermediate class, it is convenient to call the points at which faults must occur "balance points," since the relays must just balance between one type of operation and another for faults at these points.

Distance relays may be of either the impedance or reactance type, operating on the indicated impedance or reactance of the circuit from the relay to the fault, obtained by comparing the voltage and current at the relay location. These indicated impedances and reactances are approximately proportional to the distance from the relay to the fault. They do vary somewhat,

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From "Fundamental Basis for Distance Relaying on Three-Phase Systems," (**No. 31-61**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

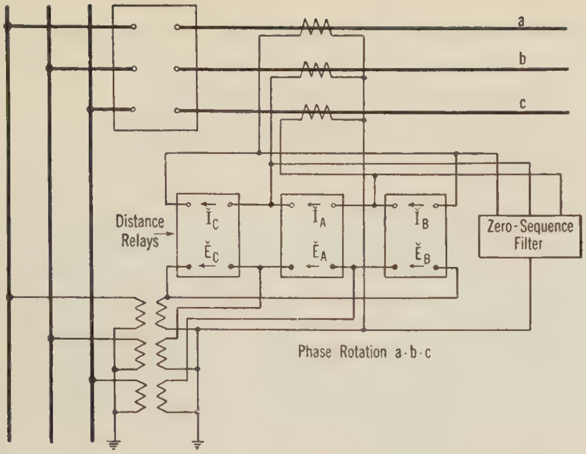

Fig. 2. Improved distance-relay connections for line-fault protection using delta-connected relays and zero-sequence filter

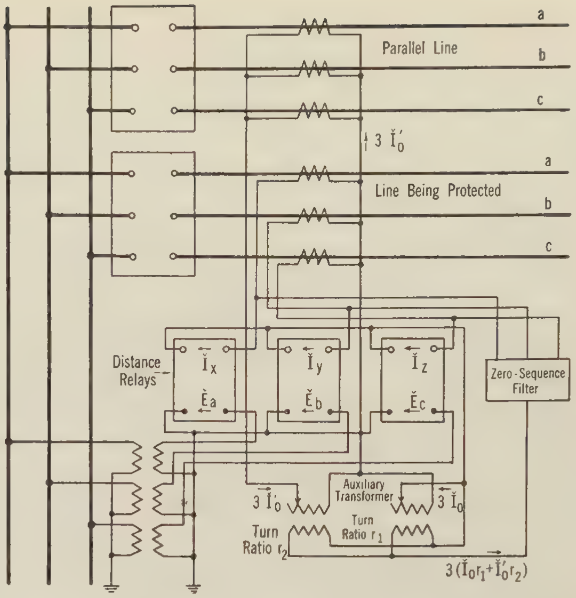

Fig. 3. Improved distance-relay connections for single-line-to-ground faults using current compensation

however, causing the locations of the balance points to shift accordingly. The greater the variation in balance point location, the larger the intermediate class must be made, and the greater are the departures from the ideal protection. If the variations in balance-point location are too great, this type of protection cannot be applied. It is, therefore, important to determine the causes of this shift in balance point and to develop methods of reducing or eliminating it.

For protection against line faults involving two or more line conductors, conventional relay connections make use of the line-to-line voltage and the line current which lags the voltage by 30 deg. at unity power factor. Analysis shows that both the indicated impedance and reactance are subject to variations for a fault in a given location dependent upon the fault resistance, current feeding the fault from the opposite end of the section, current in the remaining conductor, and current in the earth or other grounded paths. Variations in the balance points are, therefore, due to the same causes. Further analysis reveals that if "delta currents" obtained either by connecting the current transformers in delta or the current windings of the relay in delta with a suitable zero-sequence filter are used for relaying, (see Fig. 2) the two latter causes of variation are eliminated.

For protection against faults involving ground, conventional relay connections make use of line-to-ground voltage and line current. An analysis of this type of fault shows that the indicated impedance and reactance are subject to variations due to the fault resistance, the current feeding the fault from the opposite end of the section, the current in the other conductors, the mutual impedance between two parallel lines, and the difference between the impedance to balanced three-phase currents, or positive-sequence impedance and the impedance to balanced ground current or zero-sequence impedance. Further analysis shows that all of these effects except the first two may be substantially compensated, so that variations are produced only by fault resistance and the fault current feeding the fault from the opposite end of the section. This compensation may involve modifying either the current or the voltage in proper proportions. (See Figs. 3 and 4)

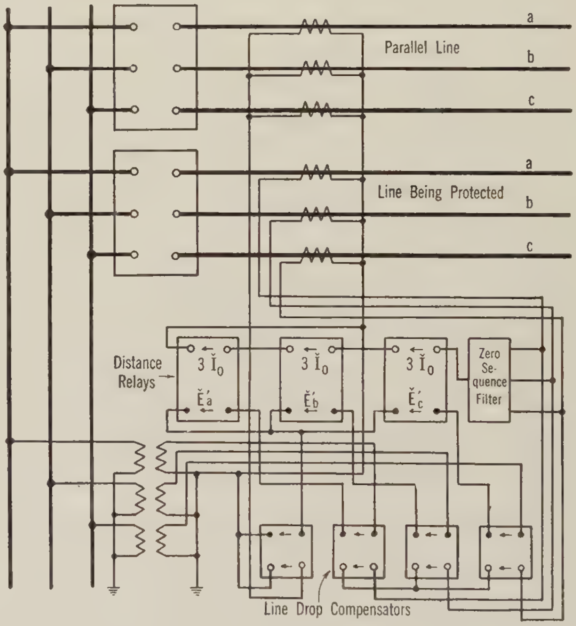

Fig. 4. Improved distance-relay connections for single-line-to-ground faults using voltage compensation

Thus, by the use of suitable methods, either the impedance or reactance type of distance relay for either line or ground faults may be made to measure accurately the distance to the fault except for the effects of fault resistance, the current from the opposite end of the section affecting the relays only when fault resistance is present. The effect of fault resistance may be represented by adding vectorially to the proper line impedance a resistance equal to the fault resistance, and a second term equal to the fault resistance multiplied by the vector ratio of two currents, these latter being functions of the currents feeding the fault from the two ends of the section, or their symmetrical components. Since the line impedance is generally principally reactive, the two resistance terms will add approximately at right angles, thus causing only moderate increases in the magnitude of the sum, unless the resistance terms are very large. The impedance relay operates on the magnitude of the sum of the three terms. This increases slightly with increasing fault resistance, and causes the balance points to shift toward the relay. On the other hand the reactance relay operates on the reactive component of this vector sum, and is therefore unaffected by the first fault-resistance term. If the two currents involved in the ratio are not in phase, the second fault-resistance term will have an apparent reactance which may be positive or negative depending upon which current is leading, so that the balance point may be shifted in either direction. Although generally the shift will be smaller than that produced by the same resistance using an impedance relay, the fact that it may be in either direction must be taken into account. Where fault resistances are moderate, as on most line faults if cleared rapidly, the total variation in balance point will often be quite comparable for the two types of relays. On ground faults the fault resistances are generally higher, so that some form of relay which is substantially independent of resistance is generally required, and accuracy thus reduced.

It should be pointed out that the design of the relay, its simplicity, reliability, and speed of operation, as well as possible accuracy, must be considered in choosing the type of distance relay to be used for a given protection.

From this analysis the following conclusions may be drawn:

1. Conventional methods of distance relaying are subject to errors other than those caused by fault impedance.

2. These errors may be eliminated in relays protecting against line faults by the use of "delta relaying," obtained either by connecting the current transformers in delta or by connecting the current windings of the relays in delta, using a suitable zero-sequence filter.

3. These errors may be eliminated in relays protecting against ground faults by the use of current or voltage compensation, and therefore if the impedance of the section being protected is sufficiently great distance relaying is suitable for ground fault protection.

4. Errors introduced by fault impedance, comprise the chief limitation in the application of distance relaying, but these decrease with increasing section impedance. This limitation affects distance relays of both the impedance and reactance types, although to different extents.

5. Distance relaying may be made to approach even more closely the desired relaying ideal, and within the limits of its application it should give satisfactory protection regardless of generator capacity or system conditions.

Shallenberger Personal Memoranda Discovered

A MEMORANDUM of Oliver B. Shallenberger, personally handwritten, and recently come to light, gives an interesting glimpse of the electrical business forty years ago. The man who left this penciled notation was one of the pioneer electrical engineers of the then infant Westinghouse company and was active in many major projects that did much to shape the course of the industry.

A young man when he first entered the electrical industry from the Navy after a course at Annapolis where he specialized in physics and electricity, he was still a young man when he died at the age of thirty-eight after fourteen years of creative effort.

His invention of the meter was in 1888 under very unusual circumstances and at a time when at least one justifiable criticism of alternating current was that there was no meter for measuring it and no motor to be used with it. In assembling a new form of arc lamp for test, a small spring dropped down between an actuating coil and an iron core; Shallenberger, standing near, noticed that the spring began to turn slowly and he restrained the attendant from picking it up with, "Let's see what makes the spring revolve." He saw and exclaimed, "There's a meter in that—and perhaps a motor!"

Shallenberger was at that time 28 years old. In 1889 he was sent abroad by his company to study European central stations. In 1891 he resigned because of ill health and spent several winters in Colorado, a victim of tuberculosis.

While in the West he conceived the idea of transmitting power from Canon City to the famous mining camp at Cripple Creek. In 1890 he had helped to promote the Telluride project of carrying power three miles—a revelation at that time; in 1897 he formed the Colorado Power Company of which he was president until his death.

Part of the time after his resignation was spent working in his own laboratory in Rochester, Pennsylvania and it was there that he studied the Cripple Creek transmission and made the notations that have been discovered.

On one side of the memorandum are listed machines and equipment with prices, weights, and freight costs which form an interesting comparison with modern apparatus. Three 470-kw. dynamos are priced at $9,000 each and weighed 37 tons. Present-day machines of corresponding rating would cost about $6,500 and weigh 17.5 tons. A lightning arrester of the type he priced at $178 would cost now only about $75.

On the reverse side of the same memorandum are notations pertaining to rates and data on an expected electric lighting load, "current 23c. kw-hr., arc lamp at $15 a month," etc.—*Contributed.*

Power Supply for Telephone Service

Automatic regulating and control equipment is finding increasing use in telephone power plants, giving more exact performance, increased reliability and reduced maintenance. Certain regulating equipment and a few of the unit-type automatic power plants recently developed are described.

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CONTINUITY and reliability of service have been keynotes guiding development of telephone power plants for many years. Duplicate equipment, reserve storage batteries, and emergency sources of power supply are regularly provided as required. A review of data available in some metropolitan districts indicates that a high percentage of continuous performance has been obtained during the past twenty years, exceeding 99.999 per cent of full time.

Provision for quick change from regular to reserve units is required, of course, while voltage regulation of the d-c. supply and frequency regulation of signaling machines are necessary for proper performance of the telephone equipment. These requirements point to the use of automatic regulating equipment and automatic power-plant operating arrangements to as large an extent as practicable, particularly since continuous service must be maintained both day and night.

Installations of automatically-controlled power equipment in small telephone offices at several towns in Pennsylvania were made during 1917 to make continuous attendance by plant employees unnecessary, particularly over week-ends. Signaling hydrometers in the two main storage batteries controlled an automatically started mercury arc rectifier to recharge the batteries as necessary. Alarms were provided to indicate any failure of equipment or abnormal discharge.

Modern automatic power plants in small offices follow somewhat similar lines except that rectifiers of the hot-cathode tube type or the dry copper-oxide disk type are employed, and control ofcharging is by means of an improved type of ampere-hour meter. Control of output voltage is frequently by relays which introduce counter cells. For larger offices is employed motor-generator equipment controlled by an ampere-hour meter, or where continuous floating at a fixed voltage is used, by various other means to bring in additional generators when the load requires them, most of the latter being still upon a trial installation basis.

The considerable variations in load current which must be furnished by the power plant are illustrated in Fig. 1, which pictures the daily load cycles in offices of several classes. Although the power required to carry a voice current over a telephone line is surprizingly small, it is not realized sometimes that the equipment necessary to accomplish this and to operate mechanical switching devices, signaling lamps, and other equipment in large offices with much traffic is considerable.

In Group *D*, (Fig. 1) for example, two-thirds of a million calls were handled during the day by three metropolitan office units operated from one power plant. Group *E* with a peak of 5,300 amperes at 24 volts represents the load of long distance switchboards and repeaters distributed over ten floors, this load being supplied by motor-generator sets having combined capacity of 10,200 amperes while the storage battery has a rating of 34,880 ampere-hours and weighs 111 tons. Some 500 hp. is required to drive these generators, while an additional 300 hp. is provided for 130-volt telegraph and repeater plate generators not shown on this group. An additional 215 hp. is provided for a vacuum-tube system to handle message slips. Part of the installed horsepower is on reserve equipment. Two other telephone power plants are in the same building. It might be mentioned that primary power is purchased from the public service companies and nearly all of it is then converted into other forms suitable for telephone use.

A brief statement of the means employed for regulating the voltage of the main d-c. power supply may be of interest, since this has assumed considerable importance from the standpoint of proper circuit operation, especially in dial offices where the automatic-switching equipment requires regulated power, and in repeater offices where the vacuum-tube amplifiers must have regulation to insure uniform transmission gain and long life of tubes.

Many years ago a single-battery group was employed, and when the output voltage was regulated, counter-e. m. f. cells were cut in during battery charging and at other times when necessary. With the adoption of duplicate batteries and the continuous floating system under which all the current is supplied to the load from the generators while batteries are held in standby service, an improvement in voltage regulation was obtained, the normal daily variation of a 24-volt battery being reduced from about seven volts to two volts. To reduce the two-volt range obtainable with hand adjustment of the generators, an automatic voltage regu-

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From "Automatic Power Plants for Telephone Offices," (No. 31-65) presented at the A. I. E. E. Middle Eastern District meeting, Pittsburgh, Pa., March 11-13, 1931

lator having several novel features was developed. One of these regulators with case open is shown in Fig. 2.

Commercial regulators available were not found satisfactory in this service since considerable "hunting" resulted from the slow response of voltage in a floated storage battery to changes of current flowing into it. This regulator includes a solenoid-operated voltage element contacting at intervals with a cam disk driven by a synchronous clock motor. The contacts are made for short periods at intervals of ten seconds, the duration of contact varying with the amount that the main-battery voltage is deviating from normal. A reversible motor drives a rheostat which varies the field excitation of the charging generator. This regulator is usually adjusted to maintain the voltage on the service bus-bars within about ± 0.15 volt. Simpler types of regulators are used on smaller installations.

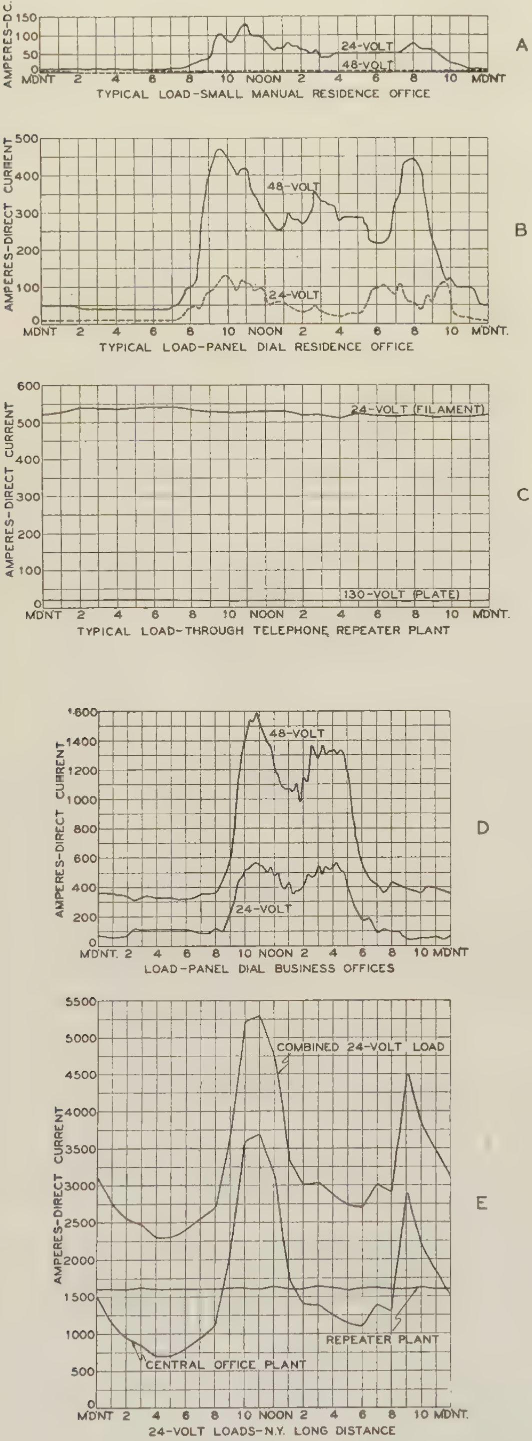

Fig. 1. Typical daily load variations in business, long distance, and residence telephone offices; morning and afternoon business peaks may be noted as well as the evening residential peak and the pick-up in long distance business as stimulated by reduced evening rates

TYPICAL UNIT-TYPE AUTOMATIC POWER PLANTS

In the development of these plants the smaller and less complicated plants were naturally attempted first; those for small private branch exchanges of the dial type, which were required in considerable number, received early attention. The dial exchange has no operators and everything must be done mechanically or, more properly, electrically, obviously requiring a more complex power plant than that of the manual P. B. X. or even of the small manual central office. In addition to a source of direct current which will continue reliable during short periods of power failure and which will be regulated as to voltage, it is necessary to provide alternating current for ringing telephone bells; also a variety of tones and signals for information and supervisory purposes. A plant which is typical of several types developed for this general class of work is shown in Fig. 3. The plant is assembled as a unit with batteries in the lower cabinet and control equipment including fuses, meters, switches, relays, ringing ma-

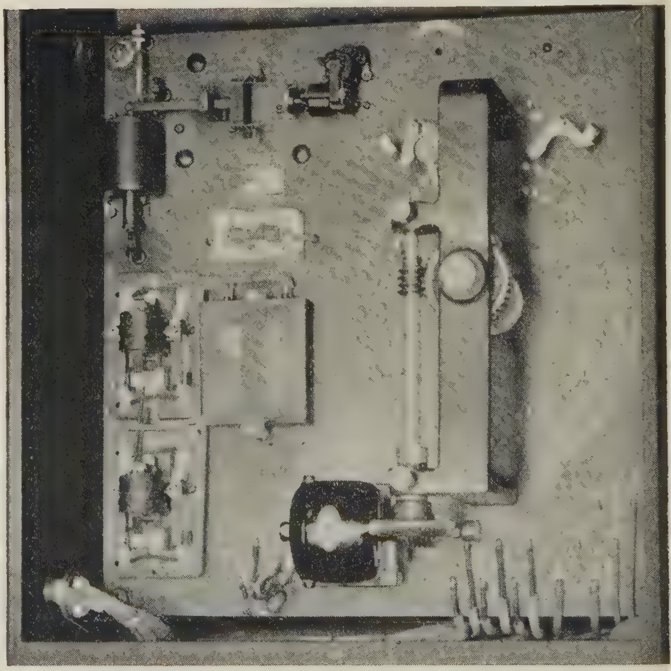

Fig. 2. Cam-type automatic voltage regulator for large machines and batteries

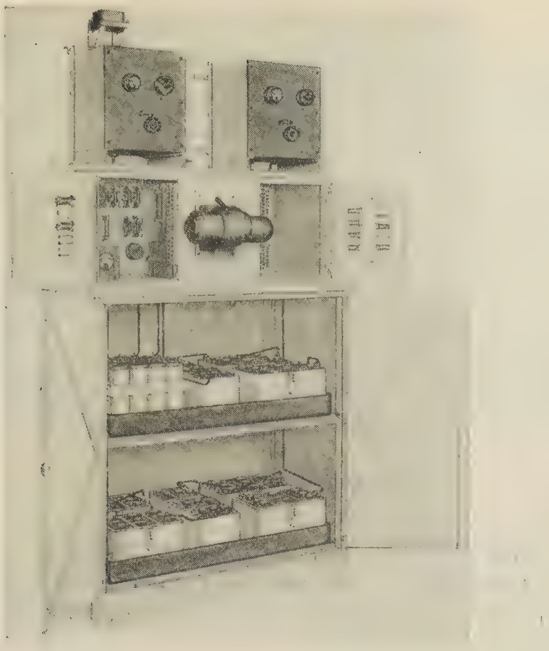

Fig. 3. Automatic power plant for dial private branch exchange; capacity 44-50 volts, 2.5-5 amperes

chine, and automatic voltage control in an upper cabinet; the charging rectifiers are mounted above. In small plants the single rectifier is mounted within the cabinet. Storage batteries are of a type assembled in groups of three cells in a glass case and are equipped with indicators to show the approximate condition of charge.

Counter e. m. f. cells used for voltage control in the small plants having but a single battery are of a new type using nickel electrodes and alkaline solution. Neither plates nor solution are affected chemically during operation, so that the maintenance consists largely in adding water to replace electrolysis loss. The small panel-mounted ringing machine is of the inverted rotary-converter type with motor element operating upon the battery and the a-c. output fed to a step-up transformer arranged to give the proper operating voltages at about twenty cycles. This machine has automatic control, starting when a receiver is lifted from the switch hook and stopping after completion of the call. It is equipped with jack-and-plug connections for ready replacement by a spare machine when maintenance is required.

In this plant the charging equipment is arranged for continuous operation at an output which will carry a large percentage of the busy-hour load and will return to the battery during the light-load periods whatever discharge has been taken plus additional current to offset battery loss. A sensitive voltmeter-type relay actuating a solenoid-type switch automatically cuts in or out the counter cells to keep the terminal voltage within a proper range. One or two three-ampere rectifiers of the hot-cathode type are provided as required.

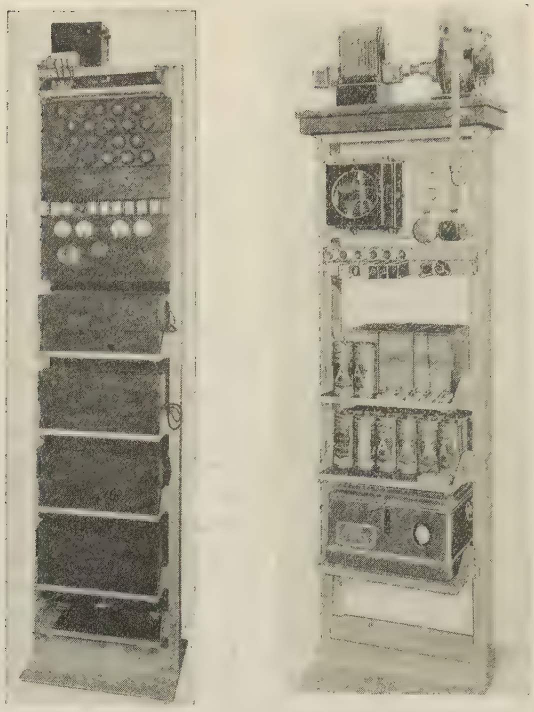

Fig. 4. (Left) Typical small plant for supplying vacuum-tube plate circuits; 125-135 volts, 50-200 milliamperes. (Right) Small plant for ringing and transmitter supply; 75-100 volts, 20 cycles and 8.5 volts direct current, 20 or 40 ampere-hours

Several plants have been designed to supply energy economically to plates and filaments of repeater tubes, and to other equipment when such energy is not available from regular central office power plants. In order to match more nearly the appearance of the repeater equipment with which these are usually associated, the equipment is mounted on floor-supported vertical channels, which carry shelves and panels. Enclosing covers are being developed for use in locations where appearance will justify the added expense or where additional protection is desirable.

Several small 130-volt plants having a range in capacity from 50 to 80 or from 50 to 200 milliamperes, and larger plants. with a capacity range from 5 to 20 amperes, are included in this series, of which a typical one is shown in Fig. 4. The smaller equipments use copper-oxide rectifiers and reserve batteries of block-type dry cells automaticaly connected into circuit upon failure of the regular power service. An unusual arrangement is employed, the dry cells being connected across the rectifier in series with a copper-oxide disk assembly acting as a valve which permits a very small current to trickle into the cells under normal conditions and interposes but little resistance when the cells pick up the load, automatically sending the current in the reverse direction during power failure.

The larger sized plants use small storage cells as reserve and also use rectifiers of the hot-cathode type. A 24-volt, 8-ampere plant for filament supply is likewise available, and similar plants of other ratings are in process.

Where current demands are heavier, the amount of energy involved and the sizes of batteries warrant the use of ampere-hour meters to start and stop the rectifiers automatically upon a schedule which insures that most of the day's load is carried directly by the charging equipment and that the reserve battery is usually maintained with from 80 to 90 per cent of its capacity available for emergency use. In addition to control contacts and adjustable overcharge shunt, the ampere-hour meter is provided with a thermocouple to increase light-load accuracy, this having been found necessary because during a considerable part of the 24-hour cycle at night the load upon the office is very small. Several sizes of plants of from 5- to 100-ampere capacity at 24, 34 or 48 volts, have been made available.

Four plants have been developed in small and compact shape to furnish economical and automatic ringing and signaling service to outlying offices, particularly of the "magneto" type in districts where subscribers' telephones have their own local batteries. One of these is shown in Fig. 4.

Ringing current is obtained from a motor-driven magneto generator except during failures of outside power when a vibrating-type ringing interrupter operated from dry cells is automatically brought into use. A small storage battery equipped with a copper-oxide rectifier in operation continuously furnishes direct current for the transmitters of the central office operators, this unit being shown upon the lowest shelf.

Larger ringing plants employing two motor-driven generators equipped with a system of interrupters to furnish machine ringing, supervisory tones, and signals, as well as positive and negative direct current for operating coin boxes, have also been developed as completely engineered and coded equipment. The regular set operates from outside power while the emergency set runs on the central office storage battery. Such equipment for a smaller office is shown in Fig. 5.

Automatic-control equipment is so arranged that the emergency set will start upon failure of ringing current from the regular set and all office ringing and signaling circuits will be automatically transferred to the reserve machine by means of 12-pole, electrically-operated switches. The frequency and voltage are automatically controlled and provision is made for return to normal condition as soon as the emergency has passed. Some of the several types of signals provided by these machines utilize interrupted battery current, making slight sparks, so that these interrupters are equipped with radio-frequency choke coils to prevent interference with nearby receiving sets. Later tone alternators of a novel inductor type which cause no interference are also available, together with low-speed interrupters of new design in which the current contacts are made and broken by mercury rolling in cast-iron channels containing an atmosphere of nitrogen.

Some unusual unit-type coded plants with automatic or semi-automatic features have been developed for special uses; only one of these, however, will be mentioned here, namely, the automatic ground-potential compensator for telegraph circuits in telephone offices. This plant, including a regular and a reserve motor-generator set, is arranged to provide a buck-or-boost voltage up to 100 volts or thereabouts in the common telegraph ground lead of an office having this equipment. It is used where unfavorable electrical and geologic conditions cause the local ground potential to fluctuate severely. The machine is controlled by a sensitive high-frequency relay connected over a pilot wire to a neutral ground several miles distant.

OPERATING EXPERIENCE

Some of the automatic-control equipment mentioned has given satisfactory service for several years, but the completely automatic plants of the present types are of recent development. Operation during a few years has been quite satisfactory; any delays under automatic control in general are less than with manual operation, while attendance of course is very greatly reduced. Alarms are provided to secure help from an attended office in the event that any of the automatic equipment should fail to perform or unexpected emergencies should develop. Success with the smaller plants described has led to installation of larger plants upon a trial basis and these also are performing satisfactorily.

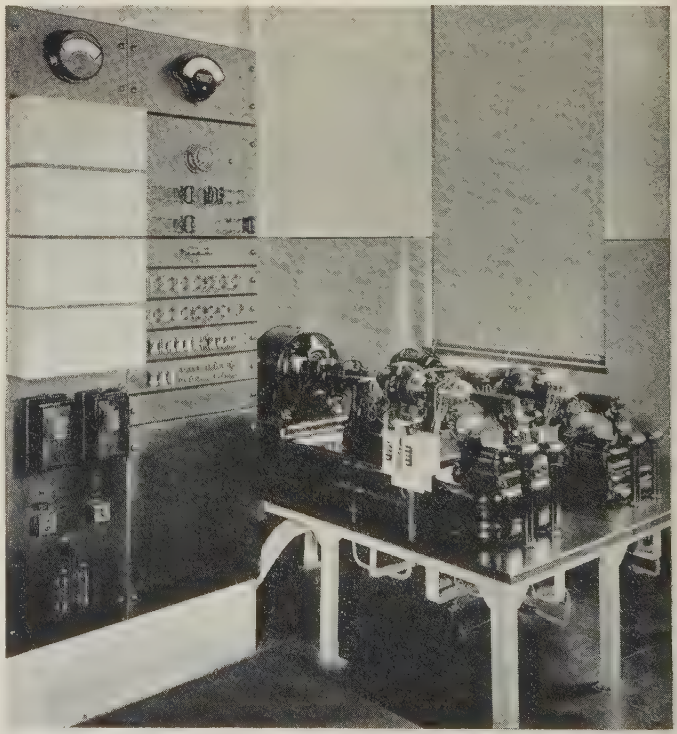

Fig. 5. Power plant for ringing and coin control; 105-100-85-77 volts, 1-8 amperes, 20 cycles and + 110, − 110 volts, 0.25-0.50 amperes direct current

Helical Grooves In Slip-Rings and Commutators

Current-collection problems can be simplified to a marked degree by helical grooves cut into the surfaces of commutators and slip-rings. Results of comparative tests before and after grooving are presented herewith.

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PERFORMANCE OF BRUSHES on slip-rings and commutators is dependent on many more or less obscure conditions. Some of these are fairly well understood and are under control so that for the most part it is pretty well known what current density, spring pressure, peripheral speed and grade of brush are best for a given brush application. There are many purely mechanical conditions that are undesirable, such as loose commutator bars, worn bearings, poorly balanced armatures, rough tracks (in traction service), friction, vibration, and loose connections; also there are dirt, oil, acid fumes and many other obstacles which influence good brush performance. In addition to these disturbing factors, however, it often is found that the current is not divided evenly between parallel-connected brushes, and this causes some of them to be overloaded.

This article is an account of an investigation into some of the causes of trouble existing right at the sliding contact, and of the series of tests conducted on helically grooved slip-rings and commutators which followed. The results show conclusively that (1) a more uniform current distribution is obtained, (2) local spot heating and glowing under overload conditions are eliminated, and (3) better commutation with cooler operation and longer brush life is assured, where these grooves are employed.

If the current density is high, a brush is likely to glow and throw off white-hot streamers, this glowing manifesting itself as a small stationary or slow-moving white-hot spot in the polished surface of the brush. Of course it cannot be seen directly, but the surrounding brush material becomes heated to a good red color ⅛ of an inch in all directions and if the small white-hot spot is near the edge of the brush, the red glow of the surrounding brush material can be seen readily.

A study of this glowing confirms the correctness of the usual explanation of the cause which is based on the negative resistance-temperature coefficient of carbon. If a brush is overloaded and one part of the brush face should by chance be a little warmer than another part, the current will have a tendency to crowd into this warmer area, raising its temperature more and more until a low-resistance hot spot is developed, which then carries substantially all of the current.

It has been observed that a hot spot of this kind will remain in one location on the brush face for many hundred revolutions of a commutator or slip-ring, during which time all sparking of the brush will be stopped. This tendency of a spot to take all the current and hold to one position on the brush face is promoted further by the local expansion of the hot carbon. This expansion causes the hot spot to become raised slightly above the polished surface and the brush rides on this "hill" until it is worn down. During this time most of the spring pressure is concentrated on the minute, raised area. Local temperature rise due to friction is thus probably a large contributing cause for bringing about the stationary hot-spot condition. When a brush is badly overloaded the hot-spot temperatures may rise to as high as 2,000 deg. cent., sufficient to graphitize the minute areas affected.

With these observations in mind it appeared that if the current passing through the hot spot could be blocked and some other portion of the brush face, or even another parallel-connected brush, could be forced to take the load for a portion of each revolution of the commutator or slip-ring, perhaps a more uniform distribution of current under the brush face and between parallel-connected brushes would result, as well as an absence of local spot heating and glowing.

Two schemes were evolved: (1) a row of side-by-side, straight-around offset grooves; and (2) the helical groove (see Fig. 1). Both schemes were tried out and gave similar results with the exception that the helical groove was easier and cheaper to make and could be cleaned more readily if necessary. In both schemes a given spot on the face of the brush can carry current and can be subjected to frictional heating for only a portion of each revolution of the slip-ring or commutator; during the remainder of the time some other spot or group of spots are forced to carry the load. Any air trapped under the brush face, sometimes a contributing factor in uneven current distribution, is permitted to escape as are any loose abrasive, solid particles of brush or ring material.

LABORATORY TESTS ON SLIP RINGS

The first tests were made to determine the effect of grooving upon contact resistance. Two copper slip-rings were used, one plain and one grooved, both mounted on the same shaft. Each was equipped with

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From "The Application of the Helical Groove to Slip-Rings and Commutators," (No. 31-38) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

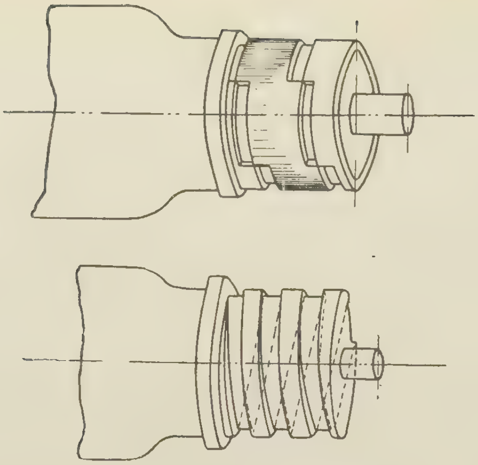


Fig. 1. The two types of grooves treated in this article. (Above) "straight around" offset groove; (below) helical groove

one positive and one negative brush and the rings were so arranged that they could be operated either in series or in parallel. At the start, with clean sandpapered rings and brushes, the contact resistance on both the rings was extremely low, but the grooved ring brush-contact resistance was almost always much lower than that of the plain ring. The resistance of both rings then slowly rose until finally after from 20 to 30 hr. the resistance of the grooved ring and brushes became about 20 per cent higher than that of the plain ring and its brushes.

While the difference in the character between the slowly formed surface film of the grooved ring and that of a plain ring is probably the main reason for the difference in the contact resistance (the 20 per cent increase), there is another well demonstrated cause. An oscillogram shows that on a plain ring a sudden, forced increase in current density at the contact between a brush and a ring causes a large but rapidly diminishing increase in the contact resistance (see Fig. 2). It would appear that with a suddenly applied current an appreciable time is required for the temperature of the current-carrying contact spots to rise, during which time the resistance (owing to the negative temperature coefficient) remains comparatively high. The helical-groove scheme furnishes means of control whereby the duration of time that any given spot on a brush face could carry a heating current and maintain frictional contact was limited to 0.02 sec. or less; and from an inspection of the oscillogram as given in Fig. 2 it appears reasonable to believe that this would account for the increase in contact resistance noted.

Another test (made at the laboratory of the Stackpole Carbon Co.) on five parallel-connected metal-graphite brushes on a plain bronze slip-ring gave frequent exhibitions of one or two brushes taking all of the current; later the same brushes run on a grooved ring were free from this trouble.

Further tests were made with a grooved and a plain ring in series and with only one brush on each ring. While the set was subjected to a heavy overload it was observed that while the plain-ring brush sparked badly the grooved-ring brush operated perfectly.

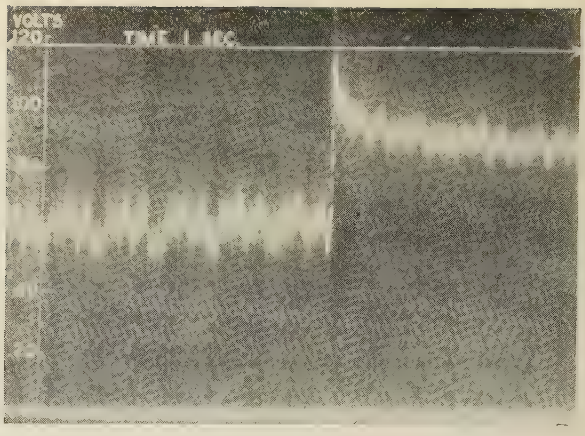


Fig. 2. Change in voltage drop on plain slip-ring as current was suddenly increased from one to seven amperes

Note the high voltage drop during the first fiftieth of a second after change. With the helical groove the current-carrying time of any given brush spot can be limited to less than 1/50 sec. thus maintaining the desirable condition of high contact drop and low operating temperature

Still another test was made on plain steel rings operating in an atmosphere of hydrogen. Concentration of current and local overheating caused pitting of the brush face and the formation of extremely hard particles (apparently iron carbide) which became imbedded in the face of the brush and rapidly scored the surface of the ring. Grooving this same ring did away with the scoring of the ring and the coarse pitting of the brush face.

Laboratory Tests on Commutators

One of the first of these tests was made on a defective 2,000-ampere 500-volt d-c. generator. This machine would carry ½ or ¾ load very satisfactorily, but on full load, trouble would develop within a few hours' time, while on 50 per cent overload, glowing, sparking, and streamers would develop at the commutator within ten minutes.

A ⅜-in.-pitch ⅛-in.-wide groove was then cut into the commutator after which the machine carried full load indefinitely (over a week) with no glowing, and withstood the 50 per cent overload for three hours; also it was noted that the grooved commutator ran 10 deg. cent. cooler than the plain commutator. Later this same grooved commutator was operated at full load and 8 of the 44 brushes removed; no distress was observed. This suggested that with grooving, commutators could be built shorter and with less expense.

A long test (200 hr.) was then made on a 40-ampere 500-volt d-c. traction motor, with first a plain and then a grooved (⅛-in. ridge, ⅛-in. groove) commutator. A

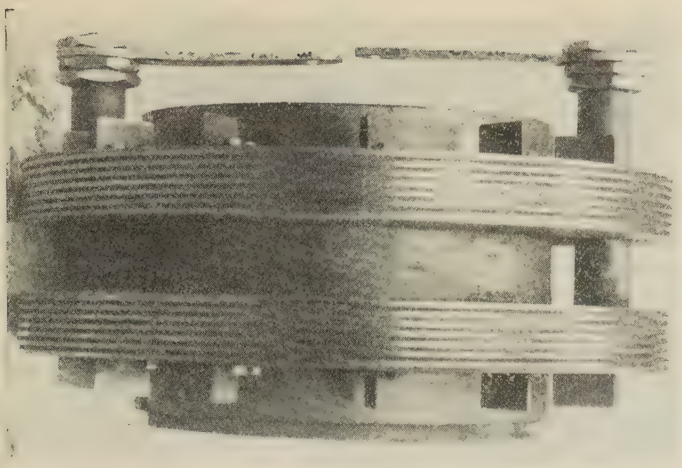


Fig. 3. Grooved slip-rings for a 15,000-kva. hydrogen-cooled synchronous condenser. The grooves are 1/8 in. wide, with a 1/8-in. ridge and a 1/2-in. pitch

reduction in sparking, a seven-degree lower operating temperature, and a more uniform current distribution between parallel brushes were noted after the commutator had been grooved; also the commutator was in better condition at the end of this test than at the end of the test made before grooving.

It appears from the above data that grooving a commutator probably does much more than simply to prevent the formation of hot spots; the cooler operation suggested that the wasteful circulating current occurring under a brush face during ordinary commutation, probably had been reduced. This can be explained only by assuming that the contact resistance had been raised. Reduction observed in the sparking at the trailing edge of brushes on a grooved commutator may be explained also by the increased contact resistance which served to cut down the volume of circulating current which the spark had to handle.

OTHER CONSIDERATIONS

The depth of groove appeared to have little or no affect upon the performance, although it is reasonable to expect that due to its increased radiating surface and the larger amount of cooling air that is dragged across the brush face a deep groove might promote cooler operation.

Width and pitch of the groove are still being studied; it would appear that to secure the best results in different kinds of service, these dimensions will vary somewhat.

When grooving a commutator it is very desirable to stone the surface after the groove has been cut in and the edges slightly rounded. Any burr left is disastrous to brush life and sandpapering alone is not effective. For subsequent polishing, a very fine sandpaper backed by a wooden block is best.

COMMERCIAL APPLICATIONS TO SLIP-RINGS

The slip-ring tests described were so convincing that when the information was divulged to one of the public service companies, this company decided to cooperate in an experiment on the rings of one of their 13,000-ampere synchronous converters. The operation proved so satisfactory that now another machine is being grooved and put into service. A second public service company is putting into operation a 15,000-kva. hydrogen-cooled synchronous condenser equipped with helically grooved steel slip-rings also running in hydrogen. (See Fig. 3).

The Calculation of Generator Heat Losses

PREDETERMINATION of the temperature in electrical machinery involves three distinct problems: (1) magnitude and distribution of the losses, (2) flow and cooling effect of the cooling medium in the machine, and (3) heat flow from source to cooling medium.

C. Richard Soderberg of the Westinghouse company in a recent A. I. E. E. paper (see foot-note) describes an unique method of calculating heat flow and heat losses within large turbine-generators under conditions of steady temperature. In his ingenious method the author utilizes "equivalent thermal circuits" for solving two-dimensional problems of heat flow.

To the third of the three problems first enumerated the author devotes his paper, which represents "an attempt at a reasonably complete solution for the heat losses in large machines with deep slots, where the temperature drops through the various iron paths are of real consequence. The analysis proceeds by progressive stages of elaboration from a simple conception of the general aspects of heat flow to what is believed to be a fairly correct picture of the complicated phenomena involved.

"Many elaborate mathemtical deductions are given . . . . Several details of the analysis have been carried to a degree of refinement which may be considered impractical for ordinary types of machines. An approximation, however, is justified only when the degree of approximation is known, and this has not always been the case with approximate methods commonly used."

From "Heat Losses in Large Turbine-Generators" (**No. 31-33**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931. (For publication in the A. I. E. E. TRANSACTIONS the title of this paper has been revised to read "The Steady Flow of Heat in Large Turbine Generators.")

Synchronizing Salient-Pole Motors

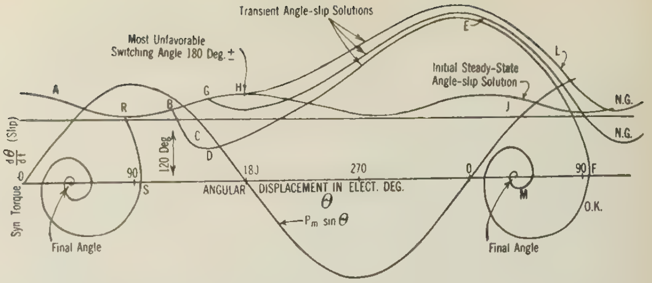
By means of the integraph the differential equation of motion for a synchronous motor during pulling-into-step transients is readily solved. An expression thus can be set up to predetermine the limiting conditions under which such a motor will synchronize.

By
H. E. EDGERTON Associate A. I. E. E. — Massachusetts Institute of Technology
PAUL FOURMARIER Non-Member — Massachusetts Institute of Technology

CALCULATION of the pulling-into-step phenomena of a synchronous motor presents one of the knottiest problems in electrical engineering. After a motor is brought up by induction-motor action to as high a speed as is possible, the field is excited with direct current and the resulting synchronizing force tends to pull the motor into step. In case the moment of inertia is small and the shaft load relatively light, the motor will have no difficulty in pulling into step. When synchronous motors are used to drive loads having large torques or large moments of inertia, a condition is approached where the synchronizing force due to the d-c. field will not be of sufficient value to pull the motor into synchronism. The principal object of this investigation was to establish a criterion between the various factors that enter into the problem of the limiting case between satisfactory and unsatisfactory operation, in order that the operation of any particular motor might easily be predetermined.

A consideration of pulling-into-step problems in general for salient-pole motors shows that the following important factors influence the phenomena:

1. Load torque on the motor shaft, which in turn determines the amount of slip when running as an induction motor.
2. Maximum available synchronizing torque, which in most motors is practically proportional to the field current.
3. Inertia of the rotor and connected rotating masses.
4. Effectiveness of the amortisseur windings and field circuit as an induction-motor rotor.
5. The displacement angle between the impressed voltage and the voltage induced by the d-c. field when the exciter is connected.



Typical integraph angle-slip solution of the equation of motion of a synchronous motor during pulling-into-step transients

6. Reluctance torque which is a function of the angular displacement.
7. The degree of unbalance in the induction-motor torque, due to the incompleteness of the amortisseur winding.

All seven of these factors appear in the differential equation of torques and solutions of this equation show their influence.

Until the advent of the integraph calculation of this differential equation was possible only by difficult, approximate methods such as step-by-step analyses and energy relations. The integraph is one of the results of the efforts of V. Bush and others at the Massachusetts Institute of Technology to find mechanical and electrical methods of solving the apparently unsolvable or tediously solvable integral and differential equations which so often are encountered in engineering work.

This investigation is a continuation of a previous study of the conditions for the pulling-into-step of a wound-rotor, synchronous motor.

The details of this investigation were published in the September 1930 issue of the *Journal of the Institution of Electrical Engineers* (London), and by it a criterion for satisfactory synchronization was evolved in terms of the moment of inertia, synchronizing torque, and other factors. The continuation here considers the effects of salient poles and incomplete amortisseur windings, the solution being obtained in a similar manner by means of the integraph.

The conclusion drawn from the study is a relatively simple empirical expression which can be used to represent the pulling-into-step characteristics of salient-pole synchronous motors, this criterion being the following:

$$s < \frac{590}{n}\sqrt{\frac{P_m}{f\,(W\,R^2)}}$$

where s = initial slip as an induction motor.
n = synchronous speed in r. p. m.
f = frequency in cycles per sec.
$W\,R^2$ = (moment of inertia in lb.-ft.)^2
P_m = maximum synchronizing power in kw. due to the field current.

According to this criterion the amortisseur windings must raise the rotor to such a speed that the average initial slip is less than the indicated function of the speed, frequency, moment of inertia, and synchronizing power, in order that synchronism may result on the first swing for the *most unfavorable switching angle.*

From "The Pulling Into Step of a Salient-Pole Synchronous Motor," (**No. 31-48**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

One of the conclusions of this study is that the reluctance torque does not influence the value of the criterion to any considerable extent. The reason for this is that the reluctance torque makes the initial slip more unfavorable than it would be if it were not present (as in wound-rotor machines) but a greater synchronizing effect is exerted by the joint action of the reluctance and synchronizing torques. These two opposite influences of the reluctance torque tend to cancel, and therefore its net effect on the ability of the motor to synchronize is inappreciable.

The degree of unbalance of the damping winding apparently also has a rather minor effect on the critical ratio. This is undoubtedly due to the fact that the rotor swings through such a large range of values of angle that only the average damping is of importance.

By means of the criterion equation, calculations of limiting slip were made for a 160-hp. synchronous motor, and according to these calculations the maximum value of slip at which the motor would pull into step was 0.0143. This represented the limiting value for the worst switching angle. In laboratory tests at these most unfavorable switching angles, the value of slip at which the motor would actually synchronize varied from about 0.014 to 0.015, which is in very close agreement with the calculated value.

A Concentrator for Printing-Telegraph Circuits

The termination in a telegraph office of a large number of "start-stop" printing telegraph circuits, requires some means for concentrating the circuits to enable incoming and outgoing traffic to be handled efficiently and economically. A multiple-turret concentrator which permits any one of many circuits to be worked by any one of a few operators is described here.

By
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Telegraph Company

DURING recent years great improvement has been made in printing telegraph systems which employ the start-stop method of synchronism. Printers adapted to such systems are known by various names, some of which are start-stop printer, simplex printer, teletype, telephone typewriter, typing telegraph and teleprinter.

The telegraph companies are using in increasing numbers printers of this type on circuits which connect to the central telegraph office the public-branch offices within a city as well as the offices of those patrons who have sufficient message traffic to warrant the telegraph companies incurring the expense of providing such a connection.

The majority of such circuits is worked intermittently and therefore the continuous services of an operator are not required at the operating terminals of each circuit. In order to handle efficiently and economically the traffic on a large number of these circuits which enter a telegraph office, there is required some means for concentrating the circuits so that any one of a large group can be worked by any one of a smaller group of operators.

Before the equipment described in this paper was decided upon, three methods of concentration were considered; (1) automatic switching of calling lines to idle operators, (2) manual switching by an arrangement somewhat similar to a manually-operated telephone private-branch exchange, and (3) lines multipled before each operator.

A study of the economics and operating advantages of these three methods, and their adaptability to the present methods of handling telegraph traffic, led to the choice of the latter arrangement; in other words, a multipled-turret concentrator.

A general view of a typical concentrator installation having 50 operating positions and a capacity of 100 lines is given in Fig. 1. It is not intended that the line capacity of this type of concentrator be limited to 100 lines; in fact installations already have been made of 200 line concentrators, and it is quite practicable to accommodate more than 200 lines with the use of the same type of equipment. The number of operating positions provided depends upon the traffic load and is determined individually for each concentrator. In actual installations of 100 line concentrators the number of operating positions has varied from 20 to 70.

All of the lines to be worked in a concentrator appear in a turret (*B*) at each operating position. These turrets are simply small switchboards connected in multiple.

Associated with each line is a relay arrangement

From "A Printing Telegraph Concentrator," (**No. 31-1**) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

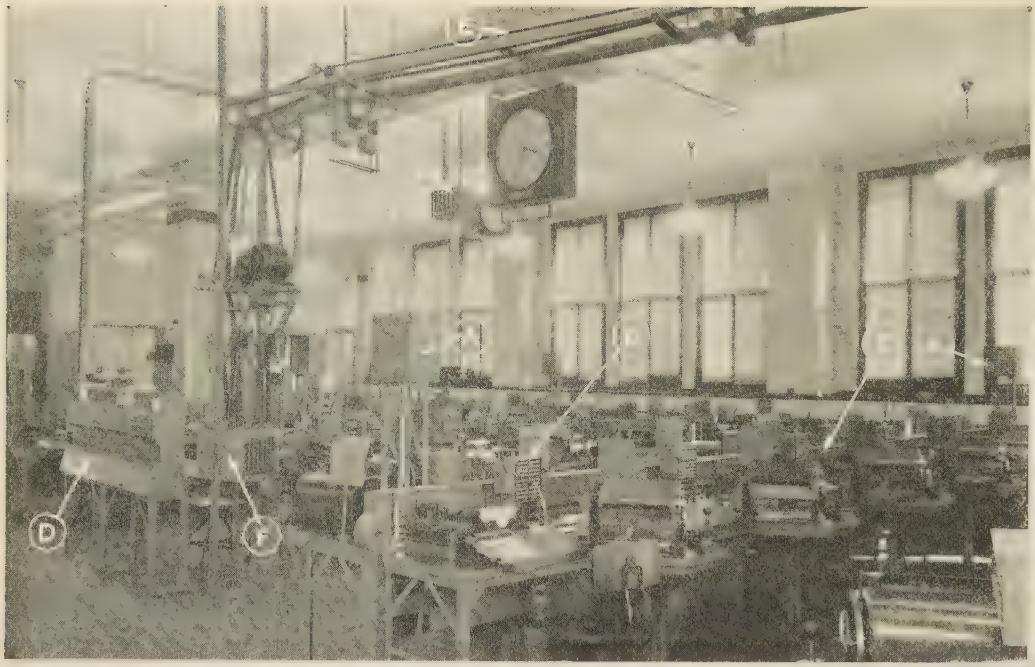

Fig. 1. General view of a telegraph concentrator showing:

A—Calling-lamp cabinet
B—Turret
C—Idle-operator indicator
D—Message routing rack
E—Message conveyer belt
F—Message drop

which serves to light the calling lamps when the outer office initiates a call. This equipment must also function to extinguish the calling lamps when an operator answers the call and must be restored to the condition where it will be in readiness to receive another call when the operator disconnects. Generally, in multiple-turret arrangements this relay device is controlled from the operating positions over a conductor separate from the line circuit, thus necessitating that an extra conductor for each line be multipled from turret to turret. Since the cost of the turrets and the cabling required to connect them in multiple is a large item in the total cost of a multipled-turret concentrator, particularly when the ratio of turrets to lines is as high as 70 or 100 an endeavor was made to simplify the turrets and reduce the number of conductors in the multiple. To this end, the concentrator is designed so that the turret multiple comprises only one conductor for each line, the control of the relay equipment which actuates the calling lamp being accomplished over the line conductor.

The use of the one conductor multiple permitted a departure from common practise in the design of the turret. Instead of jacks, the line conductors are terminated on studs molded in bakelite panels. Fig. 2 shows a 100-line turret equipped with two of these panels; over each stud will be noted the line designation. The major advantages of these panels over an equivalent arrangement of jacks and designation strips are reduced cost of apparatus and installation, and saving of space by use of a shallower turret.

Instead of associating a calling lamp with each line stud in the turrets, the lamp cabling is greatly simplified by distributing calling-lamp cabinets containing one lamp for each line among the operating positions so that each cabinet is visible to, and used by, a number of operators.

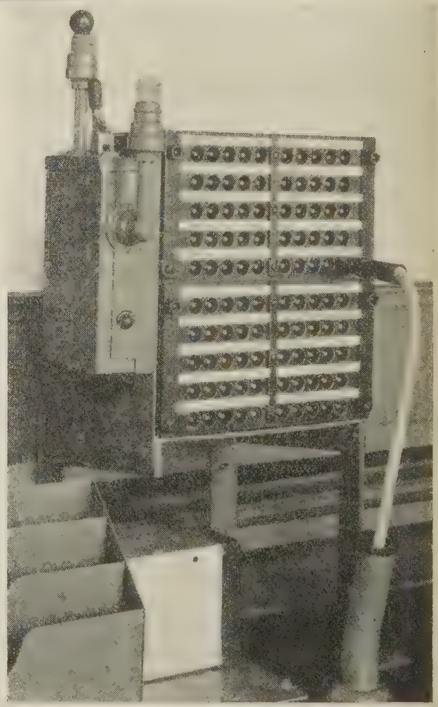

Fig. 2. Signal assembly and 100-line turret

The printer apparatus at each operating position (Fig. 3) is included in an operator's cord circuit which terminates in a jack-plug (*P*), so termed because it is used like a plug but contains springs which operate like jack springs. It is by connecting the jack-plug to a line stud in the turret that an operator connects that printer to any desired line.

When an operator at an outer office initiates a call, the calling lamps associated with this line in all of the lamp cabinets light. To avoid the confusion of all of the idle operators endeavoring to answer the call, and at the same time make sure that the call is answered promptly, the responsibility for answering is placed by virtue of an "answer-next" system upon the lowest-numbered idle operator. This system provides an answer-next lamp (*N*) on each operating position. Only one of these lamps in the entire concentrator is lighted at a time, and that lamp is always located before the lowest-numbered idle operator. This lamp glows steadily when there are no calls and flashes the instant a call appears. The operator then refers to the nearest lamp cabinet (*R*) and proceeds to attach the jack-plug to the line stud having the same relative location in that turret (*O*) as the lighted calling lamp has in the lamp cabinet. Immediately after the operator has made the connection, the answer-next lamp is extinguished and the lamp in front of the next lowest-numbered idle operator will light.

The printer (*T*) is a tape printer. During the reception of messages the operator gums the tape of each message on a telegram blank, stamps the time on the blank and then places it on a belt conveyer (*H*) which runs along the rear edge of the operating table. This conveyer feeds into a conveyer system that carries all received messages (including those received by other facilities) to the main routing center of the office.

All messages received at this main routing center and destined for an office the line of which terminates in a concentrator are dispatched by a conveyer to a message-routing rack centrally located at one end of the table rows of the concentrator as shown in Fig. 1. One or more clerks then sort these messages, according to their destination, into the proper compartment of the message-routing rack which has one compartment for each line terminating in the concentrator. Other clerks called "routing aids" immediately take these messages out of the rack and carry them to concentrator operators; messages for an office the line for which is busy are taken to the operator then working that line, while messages for an office with line idle are taken to an idle operator.

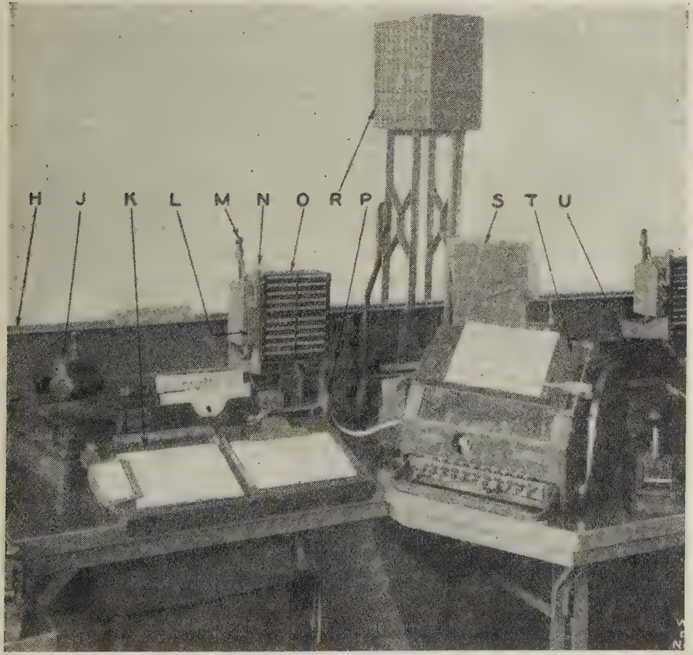

Fig. 3. A concentrator operating position

H—Belt conveyer
J—Time stamp
K—Gumming desk
L—Busy-line lamp
M—Idle-operator lamp
N—Answer-next lamp
O—Turret
P—Jack-plug
R—Calling-lamp cabinet
S—Live-message file
T—Printer
U—Number stamp

Fig. 4 shows the front view of a message-routing rack provided with 100 compartments; underneath each compartment are located five lamps utilized by the routing aids in locating the operator working any particular line. Referring to Fig. 1 it may be noted that the operating tables are divided into five distribution groups. When a line is busy, one of the five lamps associated with this line at the message-routing rack is lighted, that particular lamp denoting in which distribution group the operator then working that line is located. Thus the routing aid is guided to the proper group of tables, views the turret on each busy position, and ascertains by the location of the jack-plug which operator is working the line in question.

If none of the lamps under a particular compartment is lighted, the associated line is idle. When removing a message from such a compartment, the routing aid looks at an idle-operator indicator which is generally suspended from the ceiling and located just to the rear of the routing rack. By means of lamps this indicator shows the location of all the operators idle at that moment. As a further aid to locating the idle operators, each operating position is equipped with a green light (*M* in Fig. 3) which shows when the operator is idle.

Occasionally a message may be handed to a concentrator operator for transmission to an office which at that moment is being worked from another concentrator position. Since no busy lamps are included in the turrets, the operator is not aware of this busy condition and plugs in on the line stud. The cord circuit, however, contains an arrangement which automatically prevents the printer equipment from being connected to

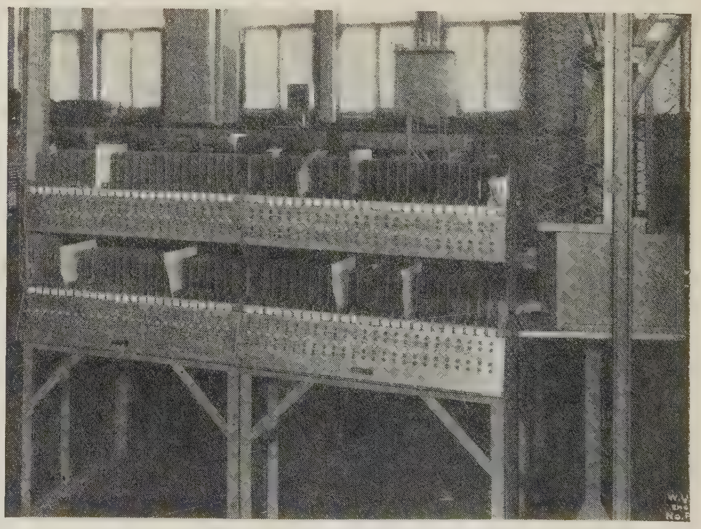

Fig. 4. Front view of message routing rack

a busy line, and furthermore, this arrangement is such that no interference is caused to printer signals which may at that moment be passing over the line circuit. The fact that the plugging in has been done on a busy line is indicated to the operator by the lighting of the busy-line lamp (*L* in Fig. 3). If the operator fails to see this signal and attempts to send on the printer, the printer due to the fact that the motor is not running will not function.

Several supervisory lamps are conspicuously located at some point about the concentrator; these lamps serve to warn the supervisor of conditions which require immediate attention, such as calls not being answered promptly or an insufficient number of operators.

All start-stop printing telegraph circuits entering the larger telegraph offices are terminated in concentrators even though some of these circuits require the individual attention of an operator during the greater part of the day.

Because the lines are of various lengths and characteristics, it is necessary to equate them for termination in a concentrator. Short lines are terminated directly in a concentrator multiple. The longer lines are terminated in single-line or duplex-half repeaters or terminal-duplex sets, the local sides of which are connected to the multiples.

Brazed Joints for Electric Conductors

Electric resistance brazing produces in electric conductors joints which possess several distinct advantages over equivalent soldered joints, and in addition can be made at a lower cost. A description of the equipment and process is given with comparative results between the two types of joints.

By
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ELECTRIC RESISTANCE BRAZING has been developed to meet the need for a better means of joining two electrical conductors. Not only have brazed joints higher heat resisting qualities and higher mechanical strength than soldered joints, but they possess high electrical conductivity as well. The simplicity of the brazing process is well illustrated by the following brief description: the parts to be joined are first clamped between a pair of carbon blocks; current is then passed through these blocks and the joints, thus heating the blocks and the parts to be joined to the melting point of the brazing alloy. The alloy, which for convenience is usually in the form of a thin strip, is then applied to the contact surfaces, is melted, and flows through the joints, uniting the parts into a solid mass.

The equipment required for making this type of joint is equally simple, consisting only of an air-cooled transformer with primary and secondary leads (the latter being connected to the brazing tongs), a foot switch, and specially designed clamping tongs for holding the work. Special transformers were designed to meet the many varying factors encountered in this work. In order to heat the parts to be brazed quickly, high current is required in the secondary circuit which is subject to momentary overloads of as high as 400 per cent. With these high currents a small reactance in the leads between transformer and tongs affects the power factor materially. For any given length of lead (7-ft. being recommended), the type of carbon block, kind of joint, and amount of contact between blocks and joint also affect the power factor.

For conductors up to 300,000 cm. in cross-section, a 5-kva. transformer has been found satisfactory; for conductors from 300,000 to 2,000,000 cm. in cross-section, a 10-kva. transformer has been found a convenient size.

The complete equipment for making joints on conductors up to 2,000,000 cm. in cross-section weighs less than 100 lb.; hence it can be transported easily from place to place. For larger joints stationary machines or presses have been adopted using much larger transformers.

Proper preparation of the work for brazing is of prime importance. Parts to be brazed should be as flat as possible so that the carbon blocks will come into intimate contact with the entire surface, thus guarding against arcing and hot spots between the blocks and parts being joined. In joining round or irregularly shaped pieces the carbons may be cut to fit the piece. In general, flat plate terminals (see Fig. 2) will replace the tubular terminals commonly used in soldered joints. If the flat plate terminal

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From "Electric Resistance Brazing," (**No. 31-16**), presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

or busbar is more than 1 in. wide, it is slotted and the brazing operation performed on each individual section as a separate operation.

Standard cable is usually prepared by wrapping with thin copper strip or inserting the end of the cable into a thin copper tube; then flattening before clamping in the tongs. If a very flat joint is desired the thin copper strip should be wound around the strands rather loosely. In all cases the wrapping or tubing should extend from ½ to 1 in. beyond the portion being brazed. Copper braid is prepared in a somewhat similar manner as may be noted in Fig. 2. In this case a copper clip about 0.02 in. thick and slightly wider than the braid is placed on the end of the braid, extending about ½ in. beyond the contact surface. Depending upon the size of the cable, insulation should be removed for a distance of ½ in. to 2 in. from the joint, the bare cable being wrapped with damp asbestos to protect the insulation from overheating during the brazing process. Flat joints are made by lapping the pieces to be brazed about 1½ times the thickness of the conductor. If it is desired to make a butt or scarf joint on rectangular conductors, this can be done by clamping the two ends together, then applying the carbon blocks to the edges of the conductor and feeding the alloy in from the flat side.

In soft soldering it is very essential that the surfaces be clean and free from oxides or other impurities. This is not so essential in brazing but certain oils and varnishes are not attacked by the brazing flux and should be removed. Generally fused borax is used for the flux, and it may be applied either in dry powder form from a small sifter or mixed with water or vaseline and applied to the joints in paste form. Depending upon the joint to be made, three different silver alloys are used as a brazing medium; these contain respectively 10, 20, and 50 per cent of silver. Alloys containing the higher percentages of silver have a lower melting point (about 730 deg. cent.) and are consequently used on small parts where temperatures must be kept down to a minimum. The 10 per cent silver alloy is satisfactory on larger cables, terminals, and busbars, where a higher brazing temperature (830 deg. cent.) is not objectionable.

The economics of adopting brazing in place of soldering are sound. Many cost studies have been made on various sizes of cables, plates, bars, and other conductors, and for purposes of comparison three typical cases are presented in Table I.

TABLE I—COST COMPARISON BETWEEN BRAZED AND SOLDERED JOINTS

Case	Preparation time	Brazing or soldering time	Finishing time	Cost of alloy or solder	Cost of labor at 60c./hr.	Total cost
1-B	3.41	3.17	1.2	0.027	0.077	0.104
1-S	3.41	5.17		0.025	0.085	0.110
2-B	10.90	7.28	4.0	0.225	0.220	0.445
2-S	10.99	17.97		0.247	0.288	0.535
3-B	5.35	15.57		0.225	0.209	0.434
3-S	5.35	24.80		0.46	0.302	0.762

In the column headed "Case,"
B—Brazed joint
S—Soldered joint
1—Terminal joined to 180,000-cm. cable
2—Terminal joined to 1,500,000-cm. cable
3—Twelve 1/8-in. by ¼-in. conductors are joined to a 770,000-cm. cable

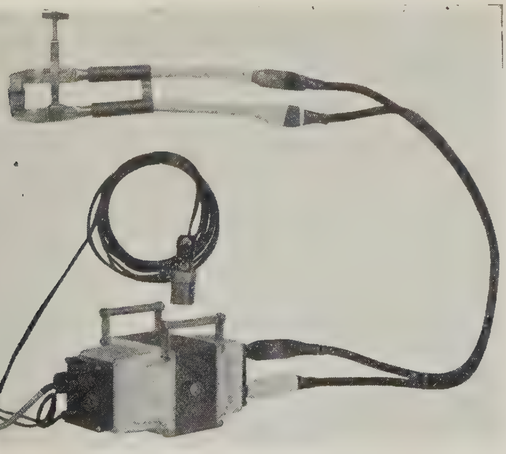

Fig. 1. Complete resistance-brazing equipment with 10-kva. transformer having 8-, 10-, and 12-volt taps on its secondary winding

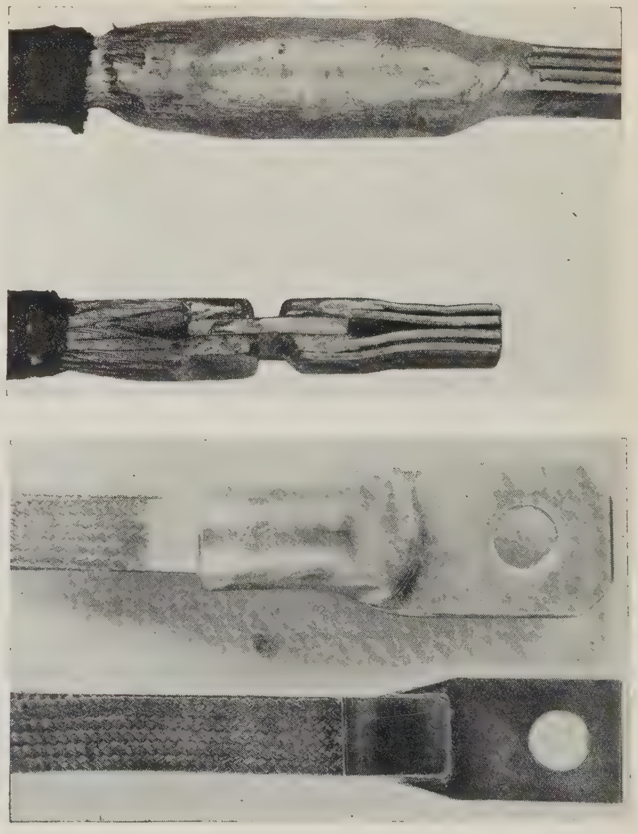

Fig. 2. A comparison between brazed and soldered joints; (above) two large conductors joined together; (below) brazed flat plate terminal and soldered tubular terminal on copper braid

In this table the preparation time includes skinning, binding, and forming the cable; finishing time is that required for cleaning. These costs have been computed for soldering under the most favorable conditions; if labor were figured at 90 cents per hour the saving on that item would be much greater.

In addition to their economic advantages brazed joints present several other distinct advantages over soldered joints. When silver solder is applied to a copper joint it dissolves a thin film of the copper surface which is very rich in copper; hence it is an excellent conductor of electricity. Since the melting point of this alloy is higher than that of the silver solder a higher temperature is always required to open the joint than to form it. If the lapped joints are designed in each case to have a contact area of at least 1½ times that of the conductor cross-section, the factor of safety is such that the joint will carry as much overload as the conductor itself. In Fig. 2 it may be seen that brazed joints besides being much more accessible for inspection are much smaller than soldered joints. These factors together with the improved mechanical strength and durability of brazed joints mark another distinct step forward in the electrical industry.

A Vacuum-Tube Voltage Regulator

A device has been developed which not only provides voltage regulation for alternators, but short-circuit protection as well. Saturation current from the filament of a thermionic tube forms the control element, while stabilization is accomplished by a feed-back system.

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VACUUM TUBES have come into general use during the past few years for controlling and regulating various types of electrical apparatus where extremely accurate regulation of speed, voltage, or other factors, is required. These applications have been confined in general to small apparatus, but few attempts having been made to adapt such means of regulation to meet the needs of large power units.

Recently, however, a regulator of this type was developed by the physics department of Cornell University, and has been in use for about two years in the laboratory on a 25-kw., 110-volt, d-c. generator. This regulator has required no readjustments or replacement of parts.

Encouraged by this performance, a similar voltage regulator has been developed for use on alternators. Operation of this regulator involves conversion of a-c. line-voltage fluctuations into corresponding d-c. variations, amplifying these and applying them to the field of an exciter which supplies the main alternator field, thus controlling the line voltage.

A schematic diagram of the regulator circuit is shown in Fig. 1. As may be noted, the amplifying system is of the ordinary resistance-coupled type. All the grid bias and plate voltages are supplied by a single "B-eliminator" system operated from the alternator being regulated. Tube filaments are lighted directly by alternating current through individual transformers also supplied from the generator under regulation.

The first tube (in this case a UX-210 type) is operated at a low filament temperature and high plate voltage, so as to obtain saturated plate current. Under these conditions the current through the coupling resistance R_2 is nearly independent of the plate voltage but changes rapidly with the filament temperature and hence with the r. m. s. value of the line voltage. This scheme was found to be superior to a grid-control method since the grid potential must be obtained from

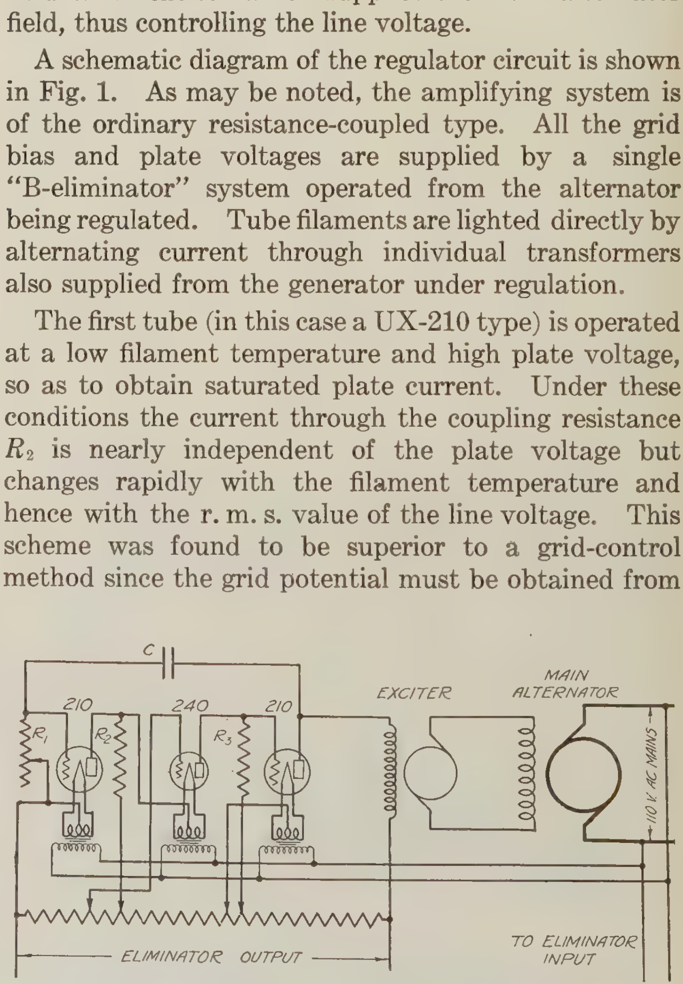

Fig. 1. Schematic diagram of regulator

From "A Vacuum-Tube Voltage Regulator for Alternators" originally submitted to the A. I. E. E. and subsequently published in full in the *Review of Scientific Instruments*, Oct. 1930.

the B-eliminator output voltage which is more closely related to the average rather than the r. m. s. value of the line voltage.

Voltage drop across R_2 is balanced out by a small adjustable portion of the eliminator output and is then applied to the grid of the second tube—a high-μ, UX-240 type. Thus a decrease in the line voltage makes the grid of the second tube more negative, cutting down the current through R_3, which makes the grid of the last tube more positive thereby building up its plate current. This increases the exciter voltage, builds up the main alternator field and boosts the line voltage. An increase in line voltage simply reverses this process.

A UX-210 type tube is employed in the last stage of the amplifier to supply the field current to the exciter generator whose field is wound to match the d-c. plate resistance of the tube. This field winding is the only special piece of apparatus used in the entire system, all the other parts being of standard make and readily obtainable.

Since the vacuum-tube system is almost instantaneous in its response to small fluctuations, the original regulator with the high amplification required for regulating a-c. machines was rather unstable in its operation. This condition, together with the comparatively long-time lags in the fields of the exciter and the main alternator, caused hunting, *i. e.*, oscillation of the line voltage about a mean value. After a good deal of experimentation it was found that the regulator could be stabilized by a feed-back coupling system composed of a condenser C and a resistance R_1, which reacts on the grid of the first tube. This virtually delays the response of the regulator, thus cutting down its tendency to over-correct.

PERFORMANCE TESTS

A number of experiments was made with this regulator connected to a 35-kva., 220-volt, two-phase alternator, operated as a single-phase machine at 110 volts —this being the rated voltage of the eliminator equipment. This constituted a severe test for the regulator, because for a given load the field-current correction necessary to maintain constant voltage is greater for low than for high voltages.

The characteristics of terminal voltage with load current at unity power factor, with and without the regulator, are given in Fig. 2. It may be noted that at full load with the regulator, the terminal voltage drops only 1.5 volts as compared with a 50-volt drop with fixed excitation.

Oscillograms (see Fig. 3) were made showing the line voltage, line current, and field current when full load at unity power factor was suddenly applied and then suddenly dropped with the regulator in operation. In these tests a regulating transformer was used to supply the B-eliminator of the regulator. This transformer was developed especially to maintain constant output voltage for a wide range of primary voltages, the load remaining constant.

With the regulating transformer in use, however, an added load of fifteen amperes at a low power factor was imposed upon the alternator and consequently the *percentage* regulation was not quite so good as when the transformer was not in use.

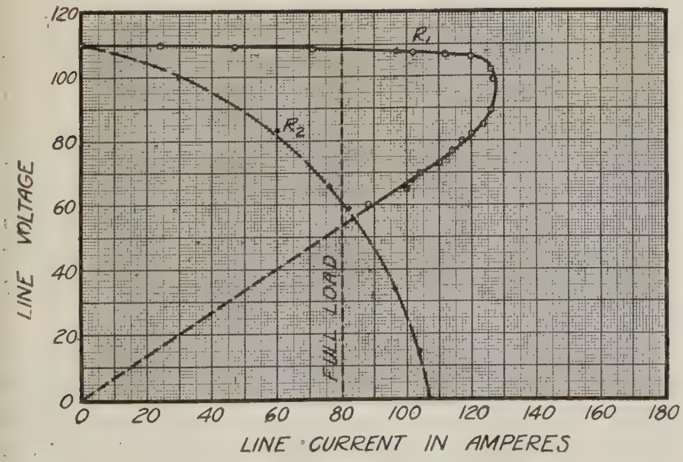

Fig. 2. Voltage characteristics of an alternator with unity-power-factor load; R_1 with vacuum-tube control; R_2, fixed excitation, without regulator

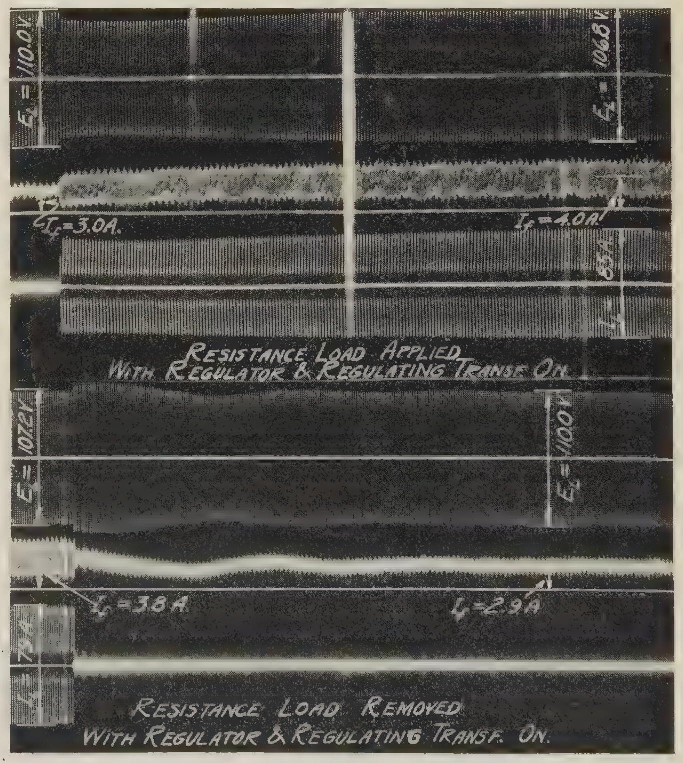

Fig. 3. Alternator terminal voltage, and field and load currents with regulator and regulating transformer in use; (above) full load is suddenly applied; (below) the load is cut off

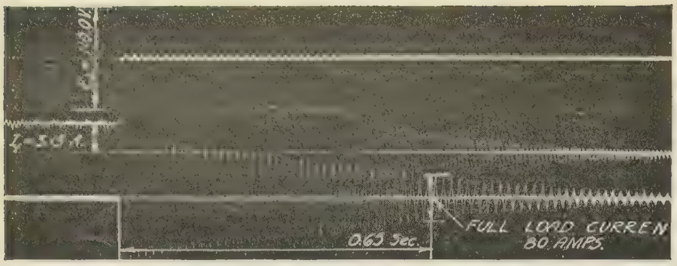

Fig. 4. Alternator voltage and current relations at time of short circuit. Note that field current is rapidly reduced to a negligible value by the protective action of the vacuum-tube regulator

PROTECTIVE ACTION

Referring again to curve R_1, Fig. 2, it may be noticed that at about 50 per cent overload the voltage starts to decrease rapidly. This is due to the fact that the B-eliminator output and the temperature of the first-stage tube filament drops sufficiently to make further regulation impossible. After the point of maximum current is reached, the system becomes unstable and the voltage drops rapidly back to zero, thus providing overload protection for the generator. The amount of overload at which the relay action starts depends upon the regulation characteristics of the eliminator as well as upon the average operating temperature of the first tube filament.

An oscillograph record showing the transient conditions occurring at short circuit with the regulator and regulating transformer in operation, is presented in Fig. 4. As may be seen, the short-circuit current is reduced to full-load value in about 0.6 sec.

FIELD CURRENT

It is shown also in Figs. 3 and 4 that the field current of the alternator is not a steady, direct current but has superimposed upon it a strong 120-cycle current. This comes from two sources: First, since the filaments of the tubes are lighted directly from the alternator, plate currents of all tubes contain a 120-cycle component which is carried right through the exciter to the main field. Second, the single-phase, 60-cycle current flowing through the windings of the armature of the main alternator induces in its field a 120-cycle e. m. f.

This 120-cycle component in the field current is of advantage, however, since the magnetic circuits of the exciter as well as the alternator are continuously carried around a hysteresis loop, thus making the average magnetic flux, and hence the generated voltage, always a single valued function of the d-c. component through the field. This field current ripple, being an even harmonic, causes no distortion in the wave form of the output voltage.

FURTHER PROBABILITIES

The regulator here described furnishes an indication of what may be accomplished by means of vacuum-tube control for power equipment. It is realized that the design might be varied to accomplish purposes other than the simple control of a single-phase machine. For example, compensation for line-voltage drop could be introduced by means of an extra winding in the filament transformer of the first tube, this winding having all or a part of the line current flowing through it. In the case of polyphase alternators a variety of schemes could be used for arranging the transformer or transformers supplying the control filament, depending upon what system voltage it is desired to control.

Motive Power for Suburban Electric Lines

Low annual car mileage together with the large number of cars required make the economical handling of suburban passenger traffic difficult. Results of a comprehensive analysis of the problem are presented.

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MAIN-LINE RAILROADS are continually becoming more important factors in providing for the rapidly increasing suburban traffic in the larger cities. Like all urban transportation, this traffic due to the poor load factor which results from the heavy rush hour peaks, places a severe burden on the railroads. These peaks are of such magnitude that the rolling stock required to provide for this traffic is from two to six times that required for the base load. On the other hand the annual mileage of suburban cars is very low compared with that of cars in through service.

An extended suburban system embraces a variety of different types of service conditions for which the motive power must be sufficiently flexible. The average length of runs vary from a mile or less to over ten miles; the train make-up, from a few cars to many. For these

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From "Motive Power for Suburban Electrification," (No. 31-15) presented at the A. I. E. E. winter convention, New York, Jan. 26-30, 1931.

varying conditions electrification is ideally suited, and the series motor with its steep speed-tractive effort curve meets the requirements of this service. For the short runs where high acceleration is desirable, this type of motor will deliver high tractive efforts with minimum demands on the distribution system. For the long runs where high-speed operation is desired, it will provide high balancing speeds. The steeper the speed-tractive effort curve, the better the motor is adapted to this service, a feature which makes the a-c. commutator motor well suited to suburban electrification.

The flexibility of multiple-unit cars enables trains of varying lengths to be easily formed and if desired the schedule speeds can be made independent of train size.

Modern practise in suburban electrifications employs accelerating rates not to exceed 1.0 to 1.5 mi. per hr. per sec. and maximum speeds of approximately 70 mi. per hr. Due to wheel slippage the maximum acceleration practical with two-motor equipment or four-motor equipment and a trailer is approximately 1.5 mi. per hr. per sec. The maximum speed may be raised to 90 mi. per hr. or more; but the advantage to be gained from this is small and the expense disproportionately large.

Previously it was mentioned that the annual mileage of cars in suburban service is quite low. On some systems the average is only about 25,000 mi. per car per annum, while the average for the entire country is only about 35,000 mi. Because of this low mileage, the fixed charges are the largest item of expense, and in some cases may exceed per car mile the combined cost of power, maintenance, and crew expense. With the electrical apparatus available today it is possible to reduce the operating costs greatly without materially handicapping the car performance. This may be accomplished in three ways.

LARGEST CARS MOST ECONOMICAL

The most economical car is that with the largest capacity which can be operated within the existing clearances. As the seating capacity of a car is increased, the cost, weight, and horsepower capacity per seat decrease, thereby reducing the power consumption, maintenance and fixed charges per seat. The chief objection to the large car however is its lack of flexibility. This objection is not so serious as it would seem, for most large electrifications today are faced with the problem of increased train length; with this increase the large car in spite of its lack of flexibility can be used to advantage. It is true that train make-up during the off-peak hours is slightly handicapped, but any increase in power during such times which might result from slightly heavier trains is more than counterbalanced by the reduced fixed charges. Recently there has been a decided tendency to reduce the car weight through the use of aluminum alloys, since a reduction in weight reduces the power consumption, and also the motor capacity. It is estimated that the saving of one pound reduces the operating costs per annum from 2.5 to 3.0 cents with an average car mileage of 35,000. Assuming 10 per cent fixed charges, it is economical to invest from 25 to 30 cents to save one pound in weight.

With any system of electrification in use today it is possible from a constructional standpoint to install on a car axle all the power which it is practical to utilize. This increased power may be employed either by increasing the schedule speeds or by handling trailers.

On large systems the average length of run is between 1.0 and 1.5 mi.; with acceleration of 1.0 mi. per hr. per sec. and a maximum speed of 70 mi. per hr., schedules from 20 to 40 per cent better than those with steam power can be maintained. An increase to 1.5-mi.-per-hr-per-sec. acceleration will increase the schedule speed only 3.3 per cent and will require motors 30 per cent larger. Likewise a 1.5-mi. per hr. per sec. acceleration and 90 mi. per hr. safe speed will increase the schedule speed only 6.6 per cent with a required increase in motor capacity of 67 per cent.

Because of the fact that the increase in schedule speed above a certain point is out of all proportion to the increase in motor capacity, it would appear to be highly economical to employ this increased capacity to handle trailers, thereby reducing the power consumption, maintenance, and fixed charges. During the off-peak hours sufficient motor cars will be available to provide all-motor-car operation which is desirable at these times. Power is relatively inexpensive as it does not increase the peak load demand; therefore any improvement in traffic resulting from better service is practically net profit.

As an illustration of trailer operation, a ten-car train composed of all motor cars will make only 3.3 per cent better schedule time than six motor cars and four trailers. In order to attain this 3.3 per cent increase in speed, an increase of 59 per cent in motor capacity is necessary. Costs of power, maintenance, and fixed charges are 22 per cent greater to deliver the *average* passenger at his destination less than *one minute* earlier.

To summarize, the most economical method of handling suburban traffic with electric motive power is, (1) to use the largest cars which can be operated within the existing clearances; (2) to reduce car weight, and (3) to operate all-motor-car trains or the equivalent during the off-peak hours with the extensive use of trailers during rush-hour periods.

LOCOMOTIVE OPERATION

On railroad systems operating extensive electrifications, the use of locomotive power on the heaviest trains may be desirable in suburban express service where the distance between stops ranges from three to ten miles. Due to the factor of diversity, locomotives may be operated both in through and suburban service with a large annual mileage, so that the fixed charges are low, making this operation economical. For short runs and small trains and when the annual locomotive mileage is low, multiple-unit cars offer better service at less expense.

News
Of Institute and Related Activities

Last Call for
The Summer Convention

ARRANGEMENTS are complete for the A. I. E. E. summer convention to be held in Asheville, N. C., June 22-26, with headquarters at the Grove Park Inn. Situated high in the southern Appalachians, Asheville offers scenic splendor of unusual interest to those who have not heretofore visited that city.

An excellent technical program has been arranged consisting of seven sessions on subjects of broad scope and current interest. Three of these sessions are symposiums; one on the important subject of power system interconnection, another on the interesting topic of communication systems for electric utilities, and the third dealing with history of electrical units, the volt, the ampere, and the ohm. Also there will be sessions on power cables, automatic stations, electrical machinery, and research.

The general convention committee has arranged an excellent series of entertainment features, sports, and inspection trips to afford visitors an attractive week of enjoyment. On Monday evening the president's reception will be held; Tuesday evening there will be a get-together dinner with entertainment; Wednesday evening the convention banquet will be given. All of these events will be held at the Grove Park Inn convention headquarters and each will be followed by dancing.

A complete list of events, tentative technical program and a description of the inspection trips was published in ELECTRICAL ENGINEERING, May, 1931, pp. 368-371. The few minor changes in program completed since the first announcement are outlined in the following paragraphs.

TECHNICAL SESSIONS

"Field Transients in Magnetic Systems" by Ernst Weber of the Polytechnic Institute of Brooklyn, N. Y., has been added to the Tuesday morning session on electrical machinery. "Residual Air and Moisture in Impregnated-Paper Insulation III" by J. B. Whitehead and F. Hamburger, Jr., of the Johns Hopkins University, Baltimore, has been transferred from the research session to the Thursday morning cables session.

GOLF—SPECIAL TOURNAMENT RULES

For golfers the main event will be the annual tournament for the Mershon Trophy, to be played over the excellent 18-hole course of the Biltmore Forest Country Club. This club is about three miles from the center of Asheville in the heart of the Biltmore Forest development. It is surrounded by beautiful homes and from almost every point there are beautiful mountain views.

It is essential that the qualifying round of the Mershon Trophy tournament be completed; this will mean that guests arriving after Monday will be unable to enter this competition.

The competition will consist of qualification round of eighteen holes, (handicap medal play) followed by match play (handicap).

The sixteen low net scores will qualify for the match play rounds, which will be played Tuesday afternoon, Wednesday afternoon, and Thursday, morning and afternoon.

Arrangements will be made by the committee for officers, section delegates, *et. al.*, to play their qualification rounds at any convenient time on Monday, so as to avoid missing their scheduled meetings.

No greens fees will be charged members or registered guests during the convention; transportation to and from all courses will be provided.

TENNIS

The annual Mershon Trophy competition in men's singles will be played, together with men's doubles, and if sufficient entries can be secured, ladies' singles and mixed doubles also.

The courts on which these games will be played will be announced later, but tennis players can be assured that excellent courts (probably clay) will be available for all who wish to use them.

Entries for all these events should be in the hands of the committee not later than Monday afternoon, June 22.

INSPECTION TRIPS

One of the three optional all-day trips scheduled for Friday, June 26, will be to the recently completed 25-acre plant of the American Enka Corporation the only Rayon plant in North Carolina. Inspection will be confined to the 4,400-kw. power plant and village only; the production units will not be open for inspection. The mill capacity is about 20,000

Biltmore Forest Country Club, Asheville, N. C., scene of the Mershon Trophy tournament June 22 and 24 lb. (75,000 miles) of viscose yarn per day.

Enka is about eight miles southwest of Asheville and, surrounded by the majestic mountains forming the southern extremity of the Appalachian range, is considered one of the beauty spots of western North Carolina. A water storage and settling basin has been constructed in the form of a picturesque 6,875-acre-ft. artificial lake on the borders of which three modern villages have been created for plant employees.

Invitations have been cordially extended by the State of South Carolina, the City of Columbia, and the Lexington Water Power Company to visit that state, its capital, and the 200,000-hp. Saluda River development near Columbia. The power company has offered to arrange for transportation from the railroad station to and from the dam where a barbecue will be given. Negotiations are pending with railway officials to run a special train from Asheville to Columbia at a reduced rate of fare.

If enough persons attending the convention evidence sufficient interest in this trip, arrangements will be completed for an all-day excursion Saturday, June 27.

North Eastern District Holds Busy Sessions at Rochester

BRINGING to a close for the current fiscal year the Institute's district meeting activities, engineers of the North Eastern District convened at the Sagamore Hotel in Rochester, N. Y., April 29-May 2. In addition to four regular technical sessions and a student convention there were held several special group meetings including a joint dinner meeting of national noise-study committees representing the National Electric Light Association, the National Electrical Manufacturers Association, the American Society of Mechanical Engineers, the American Institute of Electrical Engineers, and other organizations.

Particularly noteworthy were the many entertainment features and inspection trips arranged by the local committees. Inspection trips included visits to the plants of such widely known organizations as the Eastman Kodak Company, Stromberg-Carlson Telephone Manufacturing Company, Bausch & Lomb Optical Company, General Railway Signal Company, in addition to stations of the Rochester Gas & Electric Company. The more diversive trips included drives through the city and a trip to Niagara Falls. A delightful series of special affairs kept women guests pleasurably active and should prove a future incentive for increasing feminine attendance at these meetings. Even the needs of golf and tennis enthusiasts were ably met.

Special credit is due to everyone assisting in the supply, installation, and operation of the public address system which was a most important contribution to the success of the technical sessions. Poor audibility in meeting rooms has killed the effectiveness of more than one otherwise good meeting. The ordinary installation of stationary microphones has failed to solve the difficulties which arise with a peripatetic speaker who spends a goodly portion of his time addressing the blackboard with his back toward his auditors. At Rochester the whole problem was admirably met with the newest thing in microphones, small units attached directly to the lapel of the speaker's coat thus removing the possibility of his walking away from the "mike." The Bell Telephone Laboratories, Inc., and the Stromberg-Carlson Telephone Manufacturing Company in collaboration installed and operated the equipment.

Two of the technical sessions were devoted to miscellaneous subjects ranging from insulation research to induction-motor design. One session was given over to an exceptionally well organized symposium on the subject of noise, covering its origin, measurement, and control. Several interesting and timely subjects crowded the student session, while the closing session dwelt upon the much-investigated but always popular subject of lightning and its related problems. Some of the "high spots" of the various papers are touched upon in the paragraphs which follow.

Power Cables and Dielectrics

In presenting his paper "Temperatures in Electric Power Cables Under Variable Loading," E. A. Church (A'29), Edison Electric Illuminating Company, Boston, emphasized the need of a practical and reasonably accurate method for making these calculations to improve cable operating efficiency. He gave a solution of the problem of determining the temperature rise from sheath surface to conductor, making use of Bessel functions and resolving the heat-flow cycle into its harmonics for separate solution as well as subsequent recombination in the proper phase relation to obtain the temperature cycle. The author stated that computations based upon his theory demonstrated that the temperature curve for any cable and load cycle may readily be calculated without excessive labor and with accuracies well within the necessities of cable constants.

Theories and calculations pertaining to the "Proximity Effect in Cable Sheaths" were presented by Prof. H. B. Dwight (F'26), Massachusetts Institute of Technology, Cambridge. He described proximity effect as being the unequal distribution of alternating current over the cross-section of a conductor as caused by current in another (parallel) conductor and stated that in some cases its calculation was of importance to prove its negligibility and in other cases to prove the importance of its consideration in connection with conductor design.

Assuming cable insulation to be essentially an imperfect condenser, Prof. C. L. Dawes (M'15) and W. M. Goodhue, both of Massachusetts Institute of Technology, Cambridge, presented a discussion of "Equivalent Circuits of Imperfect Condensers" as an aid to insulation studies and calculations.

"The Theory of Thermal Breakdown of Solid Dielectrics" as described by P. H. Moon (M'29), Massachusetts Institute of Technology, Cambridge, constituted a correlation of much of the work already done on the subject of thermal breakdown. It was the author's stated aim to present this information in a form in which it could be used by the electrical engineer for the calculation of breakdown voltage. He emphasized the fact that thermal effects are but one of several mechanisms of breakdown, and that in calculating breakdown voltage, due regard must be given to this fact.

Motors and Transformers

Some of the reasons why induction motors fail to develop their expected smooth speed-torque curves were described at length by P. H. Trickey (M'30), Westinghouse Electric & Manufacturing Company, East Springfield, Mass. He stated that present knowledge attributes the undesirable "hooks" or "cusps" in the speed-torque curves to three causes at least: (1) harmonics in the field, (2) synchronous lock-in of stator and rotor harmonics, and 3) the effect of stator slots. The first of these occupied the author's attention and it was his conclusion that harmonics in the field form have a definite effect upon the speed-torque curve; also that the assumption of each harmonic acting separately is useful (though approximate) in determining the speeds at which the worst cusps will occur.

In considering the determination of "Losses in Transformers for use with Mercury-Arc Rectifiers," E. V. DeBlieux (A'30), General Electric Company, Pittsfield, Mass., reviewed theoretical calculations previously published and discussed the assumptions involved. Methods proposed for an A. I. E. E. Standard also were described and a mathematical basis for them offered. Effort is being put forth to achieve a satisfactory method for determining rectifier transformer losses independent of rectifier losses.

"The Three-Circuit Transformer" was treated at length by C. F. Estwick (M'25), General Railway Signal Company, Rochester, N. Y. That class of transformer was described as being divided into two distinct types depending upon the relative directions of the fluxes in the mutual paths of the magnetic circuit. A typical problem for each case was cited and a mathematical analysis given.

CORE-LOSS MEASUREMENT

A method and apparatus for determining the core losses in magnetic sheet steels at high-flux densities were described by B. M. Smith (A'30) and C. Concordia (A'31), General Electric Company, Schenectady, N. Y. Modern demands require machines and equipment to be designed within narrowing limits and this necessitates more attention to the accurate determination of the characteristics of materials. The authors presented data in support of their contention that now it is possible to measure core losses for densities up to $B = 20{,}000$ conveniently and accurately, and that in order to obtain a true measure of "B max." it is not necessary to maintain a sine wave of induction.

SYMPOSIUM ON NOISE

All seven of the papers presented at the noise session were liberally abstracted in the May 1931 issue of ELECTRICAL ENGINEERING (pp. 340-354); hence they will be given no further attention here.

STUDENT SESSION

President Lee (F'13) was introduced by Professor C. W. Henderson (A'20), chairman of the district committee on student activities, and emphasized very forcefully the benefits received by students who attend and participate in such meetings, stating that otherwise the contacts thus made with men and the electrical industry might not be made for months or years. He urged the young men to learn to speak and write clearly and concisely, as the presentation of reports would constitute a very important part of their engineering work.

Technical papers presented by students are outlined in the following paragraphs:

"The Theory of the Capacitance Potentiometer" as presented by A. W. Moon and W. E. Brainard, Cornell University, Ithaca, N. Y., deduced relations for the characteristics of a transformer circuit which would be suitable for use for connection across a portion of a string of high-voltage insulators. Such a connection is used now for certain instrument circuits where the cost of high-voltage instrument transformers is unwarranted; it was suggested for other possible light-load uses including radio beacons.

As a result of "Tests on 14-Megacycle Antenna Systems" reported upon by C. B. Evans, University of New Hampshire, Durham, the author stated that from experiment it appears that the most suitable radiator for 14-megacycle general amateur radio communication is a horizontal half-wavelength Hertz antenna placed as high as possible and fed as easily and as efficiently as possible. His results showed also that although antenna operation on the second harmonic is satisfactory, operation on the fundamental frequency is better.

In describing methods of "Revision of Distribution Transformer Networks,"L.O. Spencer, University of Maine, Bangor, emphasized the economic desirability of building up a system of distribution maps and records, and equipment records, particularly on the older systems and where small communities and rural areas predominate. He based his comments upon experience with a northeastern electric service company whose lines and services were severely damaged by an unusually severe sleet storm in 1929, the replacement and reconstruction of these lines being rendered extremely difficult by a lack of adequate line and equipment records.

In a "Study of the Torque-Time and Slip-Time Relation of an Induction-Motor Flywheel Set Operating on a Mine Hoist," D. C. Robinson and R. W. Stone, Syracuse (N. Y.) University, attempted to solve some of the problems of industrial-motor applications where energy demands vary over a wide range within one cycle of operation. The authors presented fairly extensive experimental results together with mathematical and graphical analyses.

Possibilities surrounding "The Piezo-electric Oscillator in the Power Industry" were described by B. H. Buckingham, Massachusetts Institute of Technology, Cambridge. Super-synchronous operation of widely separated power systems through Piezo oscillator frequency control was suggested as a possibility at sometime in the future, assuming that the crystalline structure already successfully applied to the synchronization of two or more radio broadcast stations could be developed to meet the relatively rigorous demands of power-system regulation.

"A Modern Short-Wave Amateur Transmitter," recently built by the Yale Radio Club, was described by Donald Bergener of Yale University, New Haven, Conn. The set was designed and built with particular attention to high-efficiency and stable-frequency operations in the three amateur channels, 3,500-4,000 kc., 7,000-7,300 kc., and 14,000-14,400 kc. The circuit used is the tuned-plate untuned-grid type, with a power amplifier of the class-C type, using two of the '52-type tubes. A power supply common to both oscillator and amplifier is fed from a three-phase bank of 220/2,000-volt transformers through a mercury-vapor rectifier and "brute-force" filter. In operation both the amplifier and oscillator are keyed simultaneously by changing the grid bias, thus effectively eliminating noticeable key clicks. Highly successful intercontinental communication with the set was reported.

In their "Study of the Fynn-Weichsel Motor," G. S. Brown and J. C. Gibson, Massachusetts Institute of Technology, Cambridge, presented an analytical description of that motor and its operating characteristics in the direction of power-factor correction. The authors stated that in their opinion the power-factor corrective ability of the motor is in certain cases a valuable asset, but recommended careful consideration of the local conditions in connection with each individual projected application.

Under the title "Starting Windings" P H. Trickey, University of Maine, Bangor, presented a short-cut method of designing the auxiliary starting windings of split-phase induction motors. He based his findings and mathematical analyses upon practical design experience.

SESSION ON LIGHTNING

Seven papers presented by thirteen authors dealing with various phases of the lightning problems were given at the lightning session. These papers in general fell into three classifications: (1) theory, evolution, and laboratory development; (2) studies of the effects of natural lightning on operating systems; and (3) studies based upon the imposition of artificial lightning surges upon operating systems. The paper "Characteristics of Lightning . . ." presented by F.W. Peek, Jr. (F'25), General Electric Company, Pittsfield, Mass., was devoted to showing how the various characteristics of lightning may be obtained from measurements on operating lines and how such results may be applied advantageously in developing line designs. The author stressed particularly the fact that oscillograms of traveling waves give a "remarkably complete and easily read story of the life and characteristics of the lightning which produces them." From these observed data the author described methods of determining cloud height, time of discharge, induced voltages, and current.

In discussing "Lightning Discharges and Line Protective Measures," C. L. Fortescue (A'23), Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa., and R. N. Conwell (A'15), Public Service Electric & Gas Company, Newark, N. J., described the mechanics of the development of a lightning stroke in a cloud and the formation of a surge on a line. Analyses of typical high-voltage line construction were presented to show the lightning performance obtained, and 220-kv. operating experience records were offered to substantiate the belief that induced surges are of relatively small importance; also that the direct stroke is the criterion for good design.

"Experimental Studies in the Propagation of Lightning Surges on Transmission Lines," were described by O. Brune and J. R. Eaton (A'27), Consumers Power Company, West Jackson, Mich. The authors presented reproductions of cathode-ray oscillograms to show the attenuation and distortion of artificial lightning surges on a power transmission line, the voltages induced by such surges in parallel wires, and the effect on tower-footing impedance of ground wires or counterpoises.

Lightning Experiences

Four of the papers presented were based upon data obtained from operating systems under natural lightning conditions.

Edgar Bell (A'29) and A. L. Price (A'30), Pennsylvania Power & Light Company, Hazelton, Pa., described the results obtained from the continuation of their "Lightning Investigation on the 220-Kv. System of the Pennsylvania Power & Light Company (1930)." Lightning instruments in service on this system include some 300 lightning-stroke recorders, more than a thousand surge indicators, 39 surge-voltage recorders, two cathode-ray oscillographs, three field-intensity recorders, four lightning-severity meters, in addition to magnetic oscillographs and high-speed recording ammeters at terminal stations. These authors are convinced that at least a large proportion of the lightning kick-outs on their 220-kv. system are caused by direct strokes to line structures or conductors.

Philip Sporn (F'30), American Gas & Electric Company, New York, and W. L. Lloyd, Jr. (M'27), General Electric Company, Pittsfield, Mass., presented data from the "1930 Lightning Investigations on the Transmission System of the American Gas & Electric Company." These authors reported that of 107 surges recorded on the system in Ohio, 33 per cent were caused by lightning, and 60 per cent by switching. Of the surges caused by lightning 85 per cent were positive or predominantly positive, and 8.5 per cent were purely negative (a ratio of ten-to-one). Of the surges caused by lightning, half were oscillatory and half were not. Of the oscillatory group, half were positive and half were negative.

W. W. Lewis (M'13) and C. M. Foust (A'22), General Electric Company, Schenectady, in "Lightning Investigation on Transmission Lines—II," reviewed the results of a five-year investigation of the effect of lightning on transmission systems. The authors concluded that direct strokes play a prominent part in causing flashovers, but admitted that induced strokes also seem important. These authors contended that conventional overhead ground wires with low tower-footing resistance take care of direct strokes as well as induced strokes, and operate to prevent flashovers. They also reflected and emphasized the opinion that the mechanism of a lightning stroke as yet is not understood, but that polarity effects are indicated to be of a highly important nature and worthy of careful consideration in line design.

I. W. Gross (A'12), American Gas & Electric Company, New York, and J. H. Cox (A'25), Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa., described the "Lightning Investigation on the Appalachian Electric Power Company's Transmission System." One of the characteristics of the system in question is the fact that tower-footing resistances almost universally are high, 250-ohms or more in many cases. Special equipment installed on that system at the present time includes 21 klydonographs, one cathode-ray oscillograph, and 35 direct-stroke recorders.

Inter-Society Cooperation Urged to Expedite Noise-Study Agreement

THAT the Institute should officially recognize the importance of the several angles of the noise-study situation by appointing qualified representatives to cooperate actively with corresponding groups in other societies was the concensus of opinion of the Institute members in attendance at a joint dinner meeting held at Rochester, N. Y., May 1, 1931. The dinner meeting presided over by P. L. Alger (F '30) chairman of the A. I. E. E. committee on electrical machinery and an aggressive leader in noise-study activities, closed a day devoted to the presentation and discussion of seven papers and the demonstration of four different types of noise-measuring instruments. Specialists and various committee members contributed to the dinner discussion which was centered upon an attempt at selection of definite units and methods of measurement and evaluation of noise. Without a common language for these essentials no cooperative progress can be made.

These topics have been under consideration for some time by committees of the N. E. M. A., A. S. M. E., and the Acoustical Society of America, and representatives of all these groups participated in the discussion. While no definite agreement could be reached, three principal questions were crystallized, the answers to which form a fair y complete basis for a system of noise measurement:

1. How shall the unit of noise measurement be defined?
2. What is a suitable scale of values for noise that will cover the wide range of noise intensities met with in practise?
3. What weighting factors shall be used to correlate the noises produced by sounds of different frequencies?

The accompanying table listing the characteristics of eight different proposed noise measurement systems indicates the ways in which these questions have been answered by different investigators. The conclusions of the Rochester meeting are summarized in the following paragraphs by Mr. Alger.

I—The Unit of Noise Measurement

Since all noise is the result of waves of sound pressure, it is logical to measure it in terms of dynes per square centimeter pressure to which the name "equivalent bars" might be given. Such a measurement being based wholly upon mechanical pressure will avoid many of the difficulties involved in a measure primarily based upon psychological effects which would necessarily change as more data are obtained. However, as tones of different frequencies are not equally audible, it is desirable to convert all measurements into equivalent sound pressure at a definite standard frequency. On this basis, the consensus of opinion was that:

> Noise should be measured in equivalent bars of the sound pressure produced by a pure tone of frequency 1,000 cycles per second.

VARIOUS NOISE SCALES PUBLISHED OR PROPOSED UP TO APRIL, 1931

Name	1 Pressure dynes $cm.^2$	2 Intensity	3 Sensation level loudness	4 Noise level	5 Sound level	6	7 Masking	8 Deafening
Scale	Linear	Db.	Db.	Db.	Db.	Db.	Db.	Arbitrary
Ref. pt., dynes $cm.^2$	0	6.5	Thshld.	Thshld.	0.001	0.01	Thshld.	Thshld.
Frequency		1,000	700	Street noise	1,000	1,000	Warble	Buzz
Weighted	No	Yes	Yes	Yes	Yes	Yes	Uses ear	Uses ear
			Examples					
Just painful	2,500	50	130	130	125	105	115	100
Just audible	0.0005	−80	0	0	−5	−25	0	0
Average residence	0.05	−45	32	35	30	10	20	20

Db. = decibel. Thshld = threshold. One decibel = 12 per cent change in sound pressure.

II—The Scale of Noise Measurement Values

As the range of audible sound pressure varies from 0.0005 to 2,500 equivalent bars a definition of noise in terms of pressure alone does not give a satisfactory impression of its magnitude. The logarithm of the sound pressure corresponds roughly to the sensation experienced, and this quantity is also very convenient for describing the sound transmission qualities of materials. For these reasons it was the consensus of opinion that:

> While noise may properly be expressed in equivalent bars (or milli-bars or kilo-bars), it is also desirable to express it on a logarithmic scale or in decibels where the difference in decibels between two pressures P_1 and P_0 is given by $20 \log P_1/P_0$. The zero of the decibel scale (P_0) should be taken at a convenient reference point such as 0.001 or 0.01 bars at 1,000 cycles. That is, one decibel is defined as a change in equivalent sound pressure of 12 per cent.

There was some feeling that the reference level should be taken as the threshold of audibility but the uncertainty of this level and the probability that it will change in future as more precise knowledge is gained led the majority to prefer the absolute level mentioned above.

III—Frequency-Weighting Factors

Since the audibility of sounds of different frequencies varies from zero for frequencies below about 20 cycles per sec. through a maximum at about 2,000 and down again to zero at about 20,000 cycles per sec., it is necessary to multiply the actual sound pressures by weighting factors to reduce them to a common basis. Also, since the relative audibilities of different sound frequencies vary greatly with the noise intensity, it is necessary to use different weighting factors for different levels of noise. It does not seem practical at present to have a uniformly varying weighting factor scale incorporated in a noise-measuring device, so that it seems best to establish several different weighting-factor curves for use in different zones of noise. It was the consensus of opinion, therefore, that:

> Approximately three distinct frequency-weighting-factor curves should be agreed upon, on the basis of average experimental results with a series of observers, for use in noise zones of approximately 0-20, 20-50, and above 50 db.

All noise measuring instruments should then be equipped with three networks, giving these multiplying factors for different frequencies, and all measured results should be accompanied by a statement of the network used.

IV—Additional Questions

Questions requiring further discussion, although their solutions do not seem necessary for immediate progress, are:

4. How shall allowance be made for the fact that all noise-measuring instruments so far known record the r. m. s. value of the weighted sound pressures, whereas the ear gives more weight to the notes of higher intensity, and to certain disagreeable combinations of them?

5. How shall allowance be made in commercial measurements for reflections from walls and other objects near the source of sound?

6. How shall allowance be made for the fact that low-frequency noises are more easily transmitted through structures than high-frequency noises, so that the relative sound pressures of different frequencies vary with the distance from the source?

7. How shall the commercially acceptable noise levels for different types of apparatus and different locations be defined?

It is believed that agreement on the three principal questions can be reached in a reasonable period through joint action of the committees of the several interested engineering societies. The Bureau of Standards and other laboratories have agreed to accept any conclusions reached by these engineering committees; hence responsibility rests upon the engineering societies for bringing this matter to a conclusion.

District Executive Committee Meets at Rochester, N. Y.

The executive committee of District No. 1 held a luncheon meeting on Thursday, April 30, during the District meeting in Rochester. In the absence of Vice-President I. E. Moultrop (F '29), Wellen H. Colburn (M '26) served as temporary chairman.

A. C. Stevens (M '26), secretary-treasurer of the District, presented a detailed statement of receipts and expenditures since the October meeting of the committee, and H. J. Klumb (A '16), chairman of the local executive committee for the Rochester meeting, supplied information regarding some of the expenses incurred in that connection.

It was announced that the board of directors had approved the holding of a District meeting in Providence early in May of 1932, and, after a discussion regarding the most desirable time, the dates of May 4-7 were chosen to be recommended to the executive committee for 1931-32.

Student Activities Conference Held at Rochester

The North Eastern District's annual conference on student activities was held as a luncheon meeting on Friday, May 1, with Prof. C. W. Henderson (A '20), counselor Syracuse University Branch and chairman of the District committee on student activities, presiding. Nine of the thirteen Branches in the District were represented by their counselors and chairmen; one was represented by the counselor only. Prof. Henderson was re-elected chairman of the District committee on student activities; Prof. C. L. Dawes (M '15), counselor of Harvard University Branch, and Prof. W. B. Hall, (M '28), counselor of Yale University Branch, were elected to serve with him on the executive committee of the District committee.

Professor F. M. Sebast, (M '27), counselor of the Rensselaer Polytechnic Institute Branch, and past-chairman of the District committee on student activities, presented a comprehensive report upon the types of technical papers presented in the past by students in the District, and discussed some of the factors involved in efforts to encourage all Branches to submit papers for the annual meeting.

Henry H. Henline (M '26), assistant national secretary, gave a brief summary of the types of student papers presented in such sessions in other Districts, and the subjects discussed at their conferences.

In the discussion that followed, the principal topics mentioned were (1) the desirability of active student participation in the Branches, (2) importance of interesting sophomores and juniors, (3) contacts with Sections, (4) methods of getting more of the practising engineers to attend student sessions, and (5) the importance of visits to the Branches by national officers.

Prof. W. H. Timbie (F '24), counselor of the Massachusetts Institute of Technology Branch, and chairman of the A.I.E.E. committee on student Branches, spoke briefly of the great need among high school students for accurate information on electrical engineering, and mentioned the plans of his committee to supply it.

President Lee spoke briefly upon the importance of the student activities, and mentioned the provision for allowing traveling expenses to the vice-presidents for visits to the Branches in their districts.

A Summary of Some Rochester Discussions

ONLY discussion given at the meeting and submitted in writing in accordance with governing A. I. E. E. rules is summarized; complete discussion, together with all papers so approved, will be published in the TRANSACTIONS. The titles of the papers and the names of their respective authors were published in ELECTRICAL ENGINEERING, April 1931, page 302.

ELECTRIC POWER CABLES

F. L. Buller's discussion of "Temperatures in Electric Power Cables Under Variable Loading" was read by P. L. Alger. It called attention to the statement on page six of the paper where the heat storage capacity of the lead sheath was neglected. He pointed out that in large cables the thermal capacity of the sheath was often equal to 80 per cent of that of the conductor and 25 per cent of that of the cable as a whole and for other types of cable it might even be of a larger percentage. He suggested that the equations in the paper should be analyzed to determine the effect of the omission of this factor on the results.

R. W. Atkinson discussed "Proximity Effect in Cable Sheaths" particularly formula (7) of the paper which related to sheath losses in three-conductor cables. He analyzed this formula transforming it into a convenient form of application and presented an approximate sheath-loss formula for three-conductor cables which gave values for sheath loss but from 2 per cent to 5 per cent higher than that obtained from formula (7) in the paper.

MOTORS—TRANSFORMERS

C. G. Veinott discussed "Cusps in the Speed-Torque Curves of Induction Motors." He believed that quantitatively it would be more accurate to assume the harmonic motors excited by constant primary current rather than by constant primary voltage.

G. Camilli discussed "Core Loss Measurements at High-Flux Densities" and believed it would have been of great value had data been given to show just what errors would have occurred had the older methods of measurement been used.

MAGNETIC NOISE IN SYNCHRONOUS MACHINES

H. D. Taylor discussed this subject and explained that the theory described by the authors which accounted for tooth-frequency noise was very similar to one developed by his associates and confirmed by several years' experience in designing and testing low-speed synchronous machines. Mr. Taylor's experience also confirmed the authors' statement that the worst cases of noise are likely to be associated with pole-and-slot combinations giving nearly an integral number of slots per pole. His experience with respect to the frequency of noise differed from the authors' rule. Analysis indicated that it should be a multiple of twice the line-voltage frequency times the integer nearest to the number of slots per pole.

C. E. Kilbourne discussed this subject also and explained that from a number of observations on machines having several types of rotors he had never found a case where noise could be directly traced to the rotor. Stethoscopic analysis of the stator itself indicated an increase in the volume of noise from that stator core. Another valuable part of his discussion analyzed the general equation of A. L. Ruiz for the vibration of a homogeneous ring which when there are a large number of nodes with an increased frequency is more accurate of application to this problem than is Timoshenko's equation.

MACHINERY NOISE IN BUILDINGS

J. A. Jackson discussed this subject and explained that a much closer cooperation between the electrical industry, the architects, and the consulting engineers would be needed to solve completely the noise troubles which arise in buildings. With a tendency to reduce building cost resulting in a lighter type of construction, this problem within the past few years has become increasingly difficult. Thinner walls, floors and ceilings vibrate more readily and act as sounding boards.

LIGHTNING

F. E. Andrews discussed this subject and gave data obtained by the performance of 132-kv. lines which substantiated the value of ground wires for preventing

Floodlighting at Sea

TOWERING 128 ft. above the water line, the floodlighted funnels of the new 758-ft., 42,500-ton Canadian Pacific liner "Empress of Britain" are expected to be visible for 30 miles.

interruptions. Lines of double-circuit steel-tower construction with only a single ground wire over single-circuit portions of these lines had on the average 3.78 interruptions per 100 mi. per year while parts of these lines which had double circuits with a ground wire above each circuit had only an average of 1.10 interruptions per 100 circuit miles per year.

L. V. Bewley discussed Mr. Peek's paper "Lightning" and explained that by tying down into a single set of curves (Fig. 6) the seven main factors which characterize the magnitude and shape of induced-voltage waves due to a lightning discharge, it constituted an outstanding contribution to the present knowledge of magnitudes of induced strokes. By mathematical demonstration he illustrated the application of these equations in the Appendix of Mr. Peek's paper to a specific case.

Lightning vs. Line Protection

K. B. McEachron discussed "Lightning Discharges and Line Protective Measures" and in connection with the authors' versions of the mechanism of lightning strokes he believed it would be helpful if the authors could give a more detailed explanation of just what they believed happened during the interval just before and after lightning strikes. Another point in his discussion referred to the separations between line and ground wires as shown in Figs. 3 and 4 of the paper; these he believed were unnecessarily large since many lines similar to that shown in Fig. 4 but with much smaller clearances between line and ground wires and low tower-footing resistance have had excellent operating records.

J. J. Torok's discussion of "Lightning Discharges and Line Protective Measures" was read by J. H. Cox. To supplement the general treatise of the paper the results of calculations of the effects of the tower on the reflections of traveling waves were illustrated with lantern slides. Mr. Torok also explained that the analysis and accompanying curves as presented in the paper were of considerable importance as they give for the first time a clear insight into the happenings on a transmission line at the time it is struck.

Experimental Lightning Studies

L. V. Bewley discussed "Experimental Studies in the Propagation of Lightning Surges on Transmission Lines" with particular references to the authors' conclusions about the counterpoise. He presented data from tests and equations which substantiated his belief that the major benefit to be derived from the use of a counterpoise was a reduction in true grounding resistance, and that the surge impedance and reflections are quite subsidiary effects. These results indicate that a given length of wire is most efficiently employed as a counterpoise by using it as a number of short lengths in parallel radiating out from the tower rather than as a single length. The direction of the counterpoise it was thought has no particular virtue.

J. H. Cox discussed "Lightning Investigations on Transmission Lines—II." He believed that these data were gratifying as they indicated the benefits derived from the use of a ground wire. He commended also the results contained in Table I on the use of buried cable to reduce tower-footing resistance. On the other hand he cited reasons why he did not agree with the authors that a direct stroke to a line conductor would provide necessarily sufficient voltage for insulation breakdown.

Do Streamers Build Up or Down?

K. B. McEachron discussed the mechanism of the lightning stroke and the probability of discharges proceeding from the tower to the cloud when the cloud is negative. In the light of present evidence he believed that in order to obtain definite evidence from which to build up an adequate theory further study should be given to the determination of the manner of propagation of discharges.

1931 Lamme Medal Nominations Must be Made by October 1

Special attention is directed to the fact that the names of Institute members who are considered eligible candidates for the Lamme Medal to be awarded in the Fall of 1931 may be submitted by any member in accordance with Section I of Article VI of the By-laws of the Lamme Medal Committee, as quoted in the following:

> The committee shall cause to be published in one or more issues of the A. I. E. E. Journal each year, preferably including the June issue, a statement regarding the "Lamme Medal" and an invitation for any member to present to the national secretary of the Institute by October 1 the name of a member as a candidate for the medal, accompanied by a statement of his "meritorious achievement" and the names of at least three engineers of standing who are familiar with the achievement.

Each nomination should give concisely the specific grounds upon which the award is proposed, and also a complete detailed statement of the achievement of the nominee, to enable the committee to determine its significance as compared with other candidates'. If the work of the nominee has been of a somewhat general character in cooperation with others, specific information should be given regarding his individual contributions. Names of endorsers should be given as specified above.

The Lamme Medal, founded as a result of a bequest of the late Benjamin G. Lamme, chief engineer of the Westinghouse Electric & Mfg. Company (deceased July 8, 1924), provides for the annual award by the Institute of a gold medal—together with bronze replica thereof—to a member of the A. I. E. E. "who has shown meritorious achievement in the development of electrical apparatus or machinery;" for the award of two such medals in some years if the accumulation of funds warrants.

The third (1930) Lamme Medal has been awarded to Dr. William James Foster (F '16) consulting engineer, (retired), General Electric Company, Schenectady, N. Y., "for his contributions to the design of rotating a-c. machinery;" presentation to be made during the summer convention at Asheville, N. C., June 22-26, 1931.

Edison Bust Unveiled in German Hall of Fame

Dedicated to the "spirit of indomitable research" the remarkable likeness of Thomas Alva Edison sculptured by Mrs. Evelyn Longman Batchelder was unveiled in the Hall of Honor of the Deutsches Museum, Munich, Thursday, May 7, 1931. Sponsored jointly by the Edison Pioneers and the American Institute of Electrical Engineers, this marble bust (see Electrical Engineering, Jan. 1931, p. 59), was bestowed upon the museum at the time of its annual meeting presentation being made by H. H. Barnes, Jr., chairman of the joint committee of sponsors, and on behalf of the electrical engineers of America. Response to the presentation address was given by his excellency Dr. Oscar von Millar, the genius to whom credit is due for the creation of the museum and its development to the present imposing proportions. Dr. von Millar paid tribute to Mr. Edison "as a world figure and as a benefactor of humanity."

Dr. H. Schacht, chairman of the board of directors of the museum, former president of the Reichsbank, and spokesman for German interests during the drafting of the Young Plan, presided over a group of some 400 statesmen, scientists, and industrial leaders from all over Germany.

The Deutsches Museum has arranged five rooms in its electrotechnical division, one the Hall of Honor and the others devoted respectively to historic exhibits of transformers, storage batteries, transmission materials, and the industry in general. In the Hall of Honor there is installed the first dynamo made by Werner von Siemens along with other early models of dynamos. The Edison bust is one of two accorded a position in the Hall; the other is that of von Siemens. On the pedestal of the Edison bust is inscribed:

> The great inventor to whom the world is indebted for pioneering advances in the most varied fields of scientific and engineering endeavor.

On the pedestal of the von Siemens bust there is the inscription:

> The distinguished scientist and engineer whose work created the foundation of electrotechnics.

The personnel of the joint committee which handled all details for the A. I. E. E. and the Edison Pioneers included as representatives of the Institute, H. H. Barnes, Jr. (F '13), vice-president, General Electric Company, chairman; H. P. Charlesworth (F '28), vice-president, Bell Telephone Laboratories, Inc., and a vice-president A. I. E. E.; K. G. Frank, (M '14), consulting engineer of New York; and C. E. Stephens (M '22), vice-president and northeastern district manager of the Westinghouse Electric & Manufacturing Company and a director of the A. I. E. E. John W. Lieb (deceased) was the first chairman of the joint committee. Representing the Edison Pioneers were Edward D. Adams (A '10), deceased; W. S. Barstow (F '12—Life Member), president, W. S. Barstow & Co., N. Y.; G. F. Morrison, honorary vice-president of the General Electric Company; and W. H. Meadowcroft, of the Edison Laboratories.

Lighting Pioneer Dies on Pacific Coast

Augustus D. Curtis, president and founder of Curtis Lighting, Inc., died suddenly April 29, 1931, at Beverly Hills, California, at the age of 65.

His passing culminates a life devoted to the art and science of illumination, his major contribution being the active promotion of indirect lighting and the foundation of a company dedicated to the advancement of lighting. Mr. Curtis was born at Hawley, Pa., October 14, 1865, the son of a country physician.

A. I. E. E. Directors Meet in New York

THE regular meeting of the board of directors of the American Institute of Electrical Engineers was held at Institute headquarters, New York, Tuesday, May 19, 1931. Present were: *president*—W. S. Lee, Charlotte, N. C. *Vice-presidents*—W. S. Rodman, Charlottesville, Va.; C. E. Sisson, Toronto, Ont.; G. C. Shaad, Lawrence, Kans.; H. P. Charlesworth, New York, N. Y. *Directors*—E. B. Meyer, Newark, N. J.; J. Allen Johnson, Buffalo, N. Y.; A. M. MacCutcheon, Cleveland, Ohio; F. W. Peek, Jr., Pittsfield, Mass.; C. E. Stephens, A. E. Knowlton, R. H. Tapscott, New York, N. Y.; A. B. Cooper, Toronto, Ont. *National treasurer*—W. I. Slichter, New York, N. Y. *National secretary*—F. L. Hutchinson, New York, N. Y.

The minutes of the directors' meeting of March 12, 1931, were approved. The board ratified its executive committee's action of April 3, 1931, in enrolling 66 Students; electing 128 Associates, 6 Members, and 1 Fellow; transferring 15 to Member grade and 5 to Fellow grade.

Reports of board of examiners' meetings of March 25 and April 29 were presented and approved. Upon the recommendation of the board of examiners, 138 Students were enrolled; 87 Associates were elected; 6 Members were elected; 6 applicants were transferred to the grade of Member.

Approval by the finance committee, for payment, of monthly bills amounting to $30,268.77, was ratified.

The national secretary reported 1,805 members in arrears for dues for the fiscal year which ended April 30, 1931, and was directed to transfer their names from the mailing list (after the distribution of the June and July issues of ELECTRICAL ENGINEERING) to a "suspended" list, and to employ the usual methods of collecting these dues and restoring the members to the active membership list.

The annual report of the board of directors to the membership for the fiscal year which ended April 30, 1931, as prepared under the direction of the national secretary, was considered and approved for presentation at the annual meeting of the Institute at Asheville, N. C., June 22.

The national treasurer presented a report covering the fiscal year just closed. Annual reports of the general standing committees (exclusive of the reports of the technical committees, which will be presented at the summer convention in June) were received. Abstracts of these reports were incorporated in the board of directors' annual report.

The national secretary submitted a report relating to several proposed Institute activities and upon his recommendation the president was authorized to appoint a special committee to study and report upon present and proposed Institute policies.

Authorization was given to the meetings and papers committee to schedule two papers by non-members for the summer convention.

The report of the committee on award of Institute prizes, of the awards made covering the year 1930, was presented and accepted.

Upon the recommendation of the standards committee, (1) approval was given to a minor revision of A. I. E. E. Standard No. 26 on "Automatic Stations," made by the committee on automatic stations; (2) approved for presentation to the American Standards Association for consideration as an American Standard, "Symbols for Mechanics, Structural Engineering, and Testing Materials," prepared by the sectional committee on scientific and engineering symbols and abbreviations. As a member-body of the American Standards Association, the Institute's approval was given to proposed revisions of the constitution of that organization.

A report was presented of a special committee appointed upon the recommendation of the delegates' conference at the 1930 summer convention, to consider membership grades in the Institute (below that of Member), entrance and transfer fees, etc. This report, in effect, recommended that no change be made at this time in the present arrangement of including all members below the grade of Member in the single grade of Associate, and that the entrance and transfer fees now in force be continued. Report approved.

In accordance with Section 37 of the Institute's constitution, consideration was given to the appointment of a national secretary for the administrative year beginning August 1, 1931. F. L. Hutchinson, present national secretary, was reappointed, and a resolution was adopted expressing the board's appreciation of the value of his services.

As a result of a communication from the Polish Association of Electrical Engineers, suggesting cooperation, the secretary was authorized to make arrangements with that organization for the exchange of membership privileges for visiting members, similar to the arrangements in force with several other foreign engineering societies.

An invitation to send delegates to the Fourth Pan American Commercial Conference, in Washington, October 5-12, 1931, was accepted and the president was empowered to appoint the delegates.

Other matters were discussed, reference to which may be found in this and future issues of ELECTRICAL ENGINEERING.

Who Received The First E. E. Degree?

Recent efforts upon the part of Institute headquarters to answer the question as to what American college was the first to award a degree in electrical engineering resulted in the collection of the following interesting information:

The Tufts College catalogue for 1882-83 contained an announcement of a course in electrical engineering arranged in connection with other departments of instruction extending over a period of three years and leading to a special degree.

In June 1883, F. S. Pearson received a degree in civil engineering at Tufts College, and in 1885 he was awarded a new diploma containing recognition of the fact that he had completed the course in electrical engineering. Thus, while the use of the expression "electrical engineering" in connection with a degree was first used at Tufts College in 1885, it was made retroactive by the issuing of a new diploma.

Lehigh University announced in its catalogue for 1883-84 a special advanced course in electrical engineering requiring one year for completion. The first class entered in the fall of 1884 and completed the work in June 1885, receiving certificates but not degrees. The first degrees in electrical engineering at this university were awarded in 1891.

The Massachusetts Institute of Technology announced August 1, 1882, the establishment of a four-year curriculum in electrical engineering under the administration of the department of physics, beginning with the opening of the academic year 1882-83. Two degrees for completion of this curriculum were awarded in 1885.

The Cornell University curriculum in electrical engineering was established early in 1883 as an offshoot of the department of physics, and the first degrees were awarded in 1885.

Additional information regarding early degrees in electrical engineering will be deeply appreciated by the Institute headquarters staff. Address correspondence to Henry H. Henline, assistant national secretary, A. I. E. E., 33 West 39th St., New York, N. Y.

Institute Prize Awards Announced for 1930 Papers

FOUR national prizes for papers submitted during the calendar year 1930 have been announced by the committee on award of Institute prizes, which committee consists of A. E. Knowlton (F '30) chairman, L. W. Chubb (F '21) and W. S. Gorsuch (M '17). These prizes in each case consist of $100 in cash and suitable certificates; in cases of joint authorship the cash to be divided. Personal presentation of the prizes will take place at the first session of the Institute's summer convention at Asheville, N. C., June 22-26, 1931.

District prizes as announced by five Districts include ten awards of $25 each together with appropriate certificates. As in the case of the national prizes, where there is a joint authorship the cash awards are divided.

NATIONAL PRIZES

First prize for theory and research, awarded jointly to R. H. Park (A '27) and W. F. Skeats (A '27) for their paper "Circuit-Breaker Recovery Voltages" presented at the Middle Eastern District meeting, Philadelphia, Pa., October 13-15, 1930.

First prize for engineering practise, awarded to V. M. Montsinger (F '29) for his paper "Loading Transformers by Temperature" presented at the winter convention, New York, January 27-31, 1930.

Honorable mention was made of the paper by W. B. Kirke (A '19), "The Calculation of Cable Temperatures in Subway Ducts" presented at the North Eastern District meeting, Springfield, Mass., May 7-10, 1930.

No prize was awarded in the field of public relations and education.

NATIONAL PRIZE FOR INITIAL PAPER

Initial-paper prize awarded jointly to E. E. George (M '29) and R. H. Bennett, Jr., (A '25) for their paper "Directional Ground Relays" presented at the summer convention, Toronto, Ont., June 23-27, 1930.

Honorable mention given to E. T. J. Brandon (F '20) for his paper "The 220,000-Volt System of the Hydro-Electric Power Commission of Ontario" presented at the summer convention, Toronto, June 23-27.

NATIONAL PRIZE FOR BRANCH PAPER

Branch-paper prize awarded jointly to J. R. Outt and E. H. Pemberton for their paper "Neutral Grounding Reactors for Power Systems" presented at a joint meeting of the University of Colorado Branch and the Denver Section, May 24, 1930.

Honorable mention made of the paper by G. W. Barnes "A Vacuum-Tube Wattmeter" presented at a meeting of the Oregon State College Branch, May 24, 1930.

DISTRICT PRIZES

District No. 1

First prize awarded to J. E. Clem (M '30) for his paper "Arcing Grounds and Effect of Neutral Grounding Impedance" presented at the North Eastern District meeting, Springfield, Mass., May 7-10, 1930.

Initial-paper prize awarded to F. R. Longley (A '25) for his paper "The Calculation of Alternator Swing Curves" presented at the North Eastern District meeting, Springfield, Mass., May 7-10, 1930.

Branch-paper prize awarded to F. K. Fischer for his paper "Magnetic and Electrical Properties of Some Chromium-Steel Alloys" presented at the student Branch convention, Springfield, Mass., May 9, 1930.

District No. 6

Branch-paper prize awarded jointly to J. R. Outt and E. H. Pemberton for their paper "Neutral Grounding Reactors for Power Systems" presented at a joint meeting of the University of Colorado Branch and the Denver Section, April 18, 1930.

District No. 8

First prize awarded jointly to F. E. Terman (A '13), D. E. Chambers (A '30), and E. H. Fisher (A '30) for their paper "Harmonic Generation by Means of Grid-Circuit Distortion" presented at the Pacific Coast convention at Portland, Ore., September 2-5, 1930.

Honorable mention was made of a paper by E. R. Stauffacher (M '26) "Development of a Relay Protective System on the Lines of the Southern California Edison Company, Ltd." presented at the Pacific Coast convention, Portland, Ore., September 2-5, 1930.

District No. 9

First prize awarded jointly to F. O. McMillan (M '26) and E. C. Starr (M '29) for their paper "The Influence of Polarity on High-Voltage Discharges" presented at the Pacific Coast convention, Portland, Ore., September 2-5, 1930.

Initial-paper prize awarded to E. C. Goodale (A '27) for his paper "Errors in Power Metering" presented at a meeting of the Seattle Section, May 20, 1930.

Branch-paper prize awarded to Lowell Hollingsworth for his paper "A Visual Lichtenberg Figure Voltmeter" presented at a meeting of the Oregon State College Branch, May 24, 1930, and at the Pacific Coast convention, Portland, Oregon, September 2-5, 1930.

Honorable mention was made of a paper by H. D. Garrison and L. E. Steele, "The Development of a Tesla Coil," presented at a joint meeting of the Seattle Section and University of Washington Branch, April 15, 1930.

District No. 10

First-prize awarded to T. R. Rosebrugh (A '91) for his paper "The Analytics of Transmission Calculations" presented at the summer convention, Toronto, Ont., June 23-27, 1930.

Initial-paper prize awarded to T. R. Rosebrugh for his paper "The Analytics of Transmismission Calculations" presented at the summer convention, Toronto, Ont., June 23-27, 1930.

V. D. I. Celebrates Its 74th Anniversary

On May 12, celebrating the seventy-fourth year of its existence, the Verein Deutscher Ingenieure unveiled at Alexisbad, Germany, a statue as a memorial to its founders and their aim "to coordinate the efforts of the best technical brains for the benefit of the whole industry of the country." Today the V. D. I. has 31,000 members in 53 districts and 29 local branches in Germany besides three foreign branch societies, one each in China, Argentina, and Japan.

In addition to this memorial the V. D. I. annual meeting to be held at Cologne June 27-29 will be in the form of a jubilee celebration, although true to its traditions as a scientific body, scientific events will be the chief attraction. A lecture on radiation problems, emphasizing the relation between engineering and modern physics will be the principal item of the program.

Coffin Fellowships Awarded to College Graduates

Nine college graduates have been granted fellowships for the collegiate year 1931-1932 by the Charles A. Coffin Foundation, a creation of the General Electric Company. The fellowships are to enable the recipients to engage in technical research and post-graduate work in various educational institutions. The recipients are:

J. L. Oncley, of Winfield, Kan., graduate of University of Wisconsin, to study at that institution.

E. E. Postel, of Cleghorn, Ia., a senior at University of Illinois, to study at the University of Iowa.

A. P. Gagge, of Richmond, Va., graduate of University of Virginia, to study at Yale.

G. H. Fritzinger, of Bryant, Ind., graduate of Wittenburg College, to study at Purdue University or at Massachusetts Institute of Technology.

H. E. Darling (Assoc. Student, A. I. E. E.), of Pawtucket, R. I., graduate of Brown University, to study at that institution.

J. P. Fugassi, of Pittsburgh, graduate of Carnegie Institute of Technology, to study at University of Wisconsin.

O. C. Simpson, of Champaign, Ill., graduate of University of Illinois, to study at that institution.

M. Nelles, of Madison, S. D., graduate of University of South Dakota, to study at Harvard.

D. H. Sloan, of San Francisco, graduate of Washington State College, to study at University of California.

Of these men two, Simpson and Sloan, received fellowships under the Foundation last year.

"Plan Your Vacation to Include Tahoe Convention"

As the plans for a splendid technical and social program for the A. I. E. E. 1931 Pacific Coast convention at Lake Tahoe, California, Aug. 25-28, are reaching the final stages, added inducements have developed unexpectedly. These combine with the many program features to make attendance at the convention doubly desirable.

Members of the Institute who plan to combine work and play in their vacation schedule by attending the convention may spend the week preceding or following the convention at Tahoe Tavern with the low convention rates applying during their entire stay. Since the management of Tahoe Tavern has offered the convention the attractive rates of $7.00 to $8.00 per day per person, American plan, many members are planning to take advantage of this splendid opportunity to spend the week-end before or after the convention enjoying the famous Lake Tahoe scenery.

For those traveling by automobile, several scenic routes are available through many points of historic interest. Railroad transportation to the convention is by the Overland Route of the Southern Pacific. Low summer round-trip fares with attractive stopover privileges are available from all parts of the country.

Light and Vision

The February 1931 isue of the *Transactions of the Illuminating Engineering Society* contains an analysis of the literature concerning the dependency of visual functions upon illumination intensity compiled in the form of a report prepared for the national committee on industrial lighting of the national Research Council by Dr. L. T. Troland, Lecturer on Psychology, Harvard University, Cambridge, Mass., and Head of Research Department, Technicolor Motion Picture Corp., Boston, Mass.

Prof. J. W. Barker (F '30, dean of the Columbia University school of engineering) in an editorial, in the same issue, says in part:

"In the paper which forms the body of this issue of the *Transactions*, Dr. Troland has assembled a bibliography of more than nine thousand sources from which he has critically analyzed and correlated the contents. Many portions of this analysis will be of great interest and assistance to the practical engineer, and the analysis in its entirety will serve as a compendium of reference material to which we may refer as an analytical background for much of our specialized work."

The scope of this analysis is indicated by the headings given below, taken from the table of contents of the report in question:

TABLE OF CONTENTS

I. Preface

II. Method and scope of literature search

III. Abstract of the literature bearing on the dependency of visual functions upon intensity of the stimulus

1. General survey of the problem

2. Absolute sensitivity to light
    References on absolute energy and brightness thresholds
    References on areal relations of the thresholds
    References on light and dark adaptation

3. Fechner's law: discrimination of reflection coefficients of large areas
    References on brightness discrimination threshold

4. Dependency of visual acuity upon illumination intensity
    References on visual acuity, general
    References on visual acuity as a function of intensity
    References on glare

5. Speed of vision as determined by intensity
    References on speed of vision

6. The dependency of color vision upon intensity
    References on color and intensity

7. Oculomotor functions, eye-strain, fatigue and injury
    References on the pupil and other oculomotor functions
    References on eye-strain and fatigue
    References on injury to the eye due to light

8. The influence of illumination intensity upon practical operations
    References on illumination intensity and practical operations
    Miscellaneous references

9. Summary and conclusion

Prof. Barker, in closing his editorial, says: "In publishing this analysis the Illuminating Engineering Society feels that it is making available to the world a monumental piece of work for which it thanks Dr. Troland the National Research Council."—*An "Illumination Item" contributed by G. S. Merrill, chairman A. I. E. E. committee on production and application of light, Nela Park, Cleveland.*

Personal

R. E. Doherty Accepts Yale Professorship

R. E. Doherty (M '27) for many years consulting engineer of the General Electric Company, Schenectady, N. Y., and formerly a personal assistant to Dr. C. P. Steinmetz, will become professor of electrical engineering at Yale University this fall. He will succeed Prof. C. F. Scott (HM '29 and past-president) whose retirement takes place a year from this date. Mr. Doherty is a graduate of the University of Illinois. From the student training course at Schenectady, he worked for two years in the General Electric Company's testing department; then joined the a-c. engineering department as proposition designing engineer. His work attracted the attention of Dr. Steinmetz and in 1920 he chose Mr. Doherty as his assistant. During this period of service with the "electrical wizard" he was doing postgraduate work at Union College and in 1921 he received his master of science degree. In 1922 he became the company's consulting engineer and as such achieved a monumental record. In addition to his consulting work he has had charge of the company's advanced course in engineering, a three-year course in design engineering specially planned for a small selected group of college graduates. He was a member of the G. E.'s general education committee and is deeply interested in all educational matters. For three years (1918-19 and 1926-28) he served on the Institute's educational committee. He has been a member also of the A. I. E. E. committees on electrophysics (1924-26) and power transmission and distribution (1928-29); during the period 1926-27 he served as chairman of the Schenectady local Section. He has contributed much also to technical literature.

S. M. Kintner (M '13) for some time assistant vice-president of the Westinghouse Electric and Manufacturing Company was elected its vice-president in charge of engineering at the April 29 meeting of the board. He succeeds W. S. Rugg (M '13) whom the company has made vice-president in charge of sales. As an Institute member, Mr. Kintner has been active on its committees as follows: telegraphy and telephony 1914-15; research 1927-29; representative to National Research Council, engineering division 1928-29; chairman of the research committee and on the board of award of Institute prizes 1929-30.

R. E. DOHERTY

S. M. KINTNER

J. E. CLEM

North Eastern District 1930 Prize Winners

F. K. Fischer, a member of the A. I. E. E. student Branch at Rensselaer Polytechnic Institute received the 1930 Branch Paper prize for his paper "Magnetic and Electrical Properties of Some Chromium Steel Alloys" presented as a part of the program of the North Eastern District meeting at Springfield, Mass., and the basis of the thesis upon which Mr. Fischer earned his E. E. degree at time of graduation June, 1930. This thesis has since been published as a Rensselaer Polytechnic Institute Bulletin, Engineering and Science Series. In July Mr. Fischer joined the student Test Course of the Westinghouse Electric and Manufacturing Company at East Pittsburgh and at present is a member of the Westinghouse Mechanical School of Design run in cooperation with the Graduate School of the University of Pittsburgh.

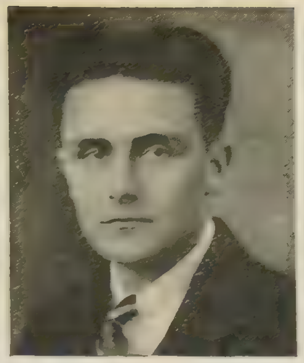
J. E. Clem (M '30) received the 1930 Best Paper prize of the North Eastern District, A. I. E. E., for his paper "Arcing Grounds and Effect of Neutral Grounding Impedance" presented at the Springfield meeting of the District in May, 1930. Mr. Clem was graduated from the University of Colorado in 1910 with the degree of B. S. in E. E. During the summer of that year he joined General Electric staff in Schenectady, N. Y. In 1922 he went to Japan to supervise the initial installation of 154-kv. transformers in that country, returning in 1925 to become a member of the central station engineering department at Schenectady. Mr. Clem is the author of several Institute papers, and is active in Institute affairs.

F. R. Longley (A '25) received the North Eastern District's 1930 First Paper prize for his paper "The Calculation of Alternator Swing Curves" presented at the District meeting in Springfield in May, 1930. Mr. Longley was graduated from the Georgia School of Technology, Atlanta, in 1923 with the degree of B. S. in E. E. During that summer he joined the General Electric staff in Schenectady where he spent time "on test" and subsequently in the a-c. engineering department. Later, in the central station engineering department he made a special study of stability problems. Mr. Longley left the employ of the General Electric Company in July, 1930, to become associated with the Western Massachusetts Companies with headquarters in Springfield.

B. M. Jones (M '24) general engineer of the Duquesne Light Company, Pittsburgh Pa., has become the company's planning engineer, and as such will be directly responsible for the planning and development of the Duquesne system as well as the preparation and administration of the capital improvement budget. For many years Mr. Jones has taken an active part in Institute affairs as member of the relay subcommittee and the oil circuit breakers, switches, and fuses subcommittee of the protective devices committee (still serving); and the membership committee of the Pittsburgh Section. He has done considerable work in connection with the committee on uniform procedure for testing oil circuit breakers for interrupting capacity; was joint author with G. B. Dodds in the presentation of "Ground Relay Protection for Transmission System" at the Detroit A. I. E. E. summer convention.

E. J. Jonas (M '23) is the new president of the Central Electric Railway Master Mechanics' Association, Toledo, Ohio. His success as superintendent of the Cincinnati Street Railway Company has made him eminent in mechanical and electrical engineering circles in Cincinnati, as did his work on the standing committee of the Institute's local Section there; he also has served twice on the A. I. E. E. nominating committee. Two years ago he was elected vice-president of the

F. R. LONGLEY



F. K. FISCHER

R. W. E. MOORE

Master Mechanics' association, and its program committee chairman.

Chester Lichtenberg (M '13) who has been intimately identified with technical committees of the Institute, the N. E. L. A., N. E. M. A., and the War Department's procurement planning activities, recently was appointed engineer of the electric refrigeration department at the Fort Wayne Works of the General Electric Company, after nearly twenty-five years with that company in the development of switchboard apparatus, particularly in connection with high-speed air circuit breakers, oil circuit breakers, and selective protective relays.

E. A. Olsen (M '24) formerly vice-president of the Pacific Public Service Company and managing head of its public utility properties serving California, Oregon, and Washington communities, has accepted the position of executive vice-president of the Oklahoma Natural Gas Corporation with offices at Tulsa. Associated with the Insull interests Mr. Olsen held similar office with the Florida Power Corporation and the Georgia Power & Light Company.

R. W. E. Moore (M '17) who until June 1 was with the Westinghouse Company at East Pittsburgh, Pa. as manager of association activities, has been appointed by the National Electric Manufacturers Association to take charge of its publications. For many years Mr. Moore was a member of the Electrical Manufacturers Council as well as chairman of the NEMA Fire Prevention committee.

Alexander E. Bettis (F '26) one of the Institute's directors, and at present serving on its safety code, production and application of light, and transportation committees for 1931, has been chosen president of the Missouri Association of Public Utilities. Mr. Bettis is at present serving the Kansas City Power & Light Company as its vice-president. In 1926-28 he was vice-president of the Institute's South West District.

J. W. Young (A '22) who as engineer of the Narragansett Electric Company went to Providence two years ago to participate in distribution system improvement, has been transferred to the Boston office of the New England Power Association to serve as assistant distribution engineer under W. C. Phillips (M '30) in charge of the development of retail properties of the organization.

W. H. McGrath (M '20) formerly vice-president of the Puget Sound Power & Light Co., Seattle, Wash., has been made its executive vice-president and C. C. Curtis (M '23) previously vice-president in charge of the Fall River Gas Works, Fall River, Mass. has been appointed manager to supervise the Puget Sound Company's operations in its southern, southwestern, and western districts.

Thos. E. Penard (A '08) who during his many years of service with the company has specialized in station design and substation development as head of the electrical division of the Edison Electric Illuminating Company of Boston has been appointed recently to the office of assistant superintendent of its station engineering department.

Gerard Swope, (F '22) addressed the plenary session of the sixth general congress of the International Chamber of Commerce meeting May 4-9, 1931, Washington, D. C., taking as his subject "Regularization of Employment" and presenting the various points of view of company, trade and industry, society, and employee.

L. C. Halpin (A '26) until recently meter superintendent for the Western division of the Niagara Lockport and Ontario Power Company, has been made rural representative of the Angola district in charge of distribution. Mr. Halpin is a member also of the Western Society of Engineers.

Karr Parker (M '24) well known in the Westinghouse organization as president of that company's Agent Jobbers Association, is the newly elected president of McCarthy Bros. & Ford, Buffalo, N. Y., Westinghouse jobbers. He succeeds E. D. McCarthy whose death occurred recently.

H. T. Edgar (M '28) who entered the public utility field in 1886 as an employee of the Edison Electric Illuminating Company of Brunswick, N. J., and for the past thirty-two years associated with Stone & Webster in managerial work extensively throughout the country, has resigned from that organization.

A. M. Chitty (M '22) who has succeeded R. C. Saunders as southwestern district manager of the Puget Sound Power & Light Company, with headquarters at Tacoma, Wash., has a record of long standing with these interests, having been for many years superintendent of the company's traction properties.

Frank W. Smith (M '12) vice-president and general manager of the United Electric Light & Power Company, New York, N. Y. and a former president of the National Electric Light Association, now is vice-president of the New York Edison Company as well.

A. R. Nissar (M '16) principal of the Calcutta Technical School, Bengal, India, left Calcutta the first week in April 1931 for an extended trip to France, Italy, Switzerland, Holland, Germany, and Great Britain.

J. H. Cerecedo (A '20) of the firm of J. H. Cerecedo & Company, Santurce, Porto Rico, Pan-American consultants, has announced the opening of an office in the United States in Chicago, at 105 South La Salle Street.

J. S. Edstrom (F '14) managing director of the General Electric Company interests in Sweden, recently visited the United States as a delegate to the World Congress of the International Chamber of Commerce, Washington, D. C.

R. H. Manahan (M '22) who is chief of the Department of Electricity of the City of Los Angeles and for many years active in the affairs of the International Association of Electrical Inspectors, now has become its national president.

F. R. Phillips (M '27) for some time senior vice-president of the Philadelphia Company was elected president of that company at the April 28 stockholders' meeting.

Obituary

Edward Dean Adams (A '10), engineer, financier, scientist, whose vision, industry, courage, and philanthropy has made possible many achievements of outstanding worth to humanity, including the conception and development of the Niagara Falls hydroelectric system, passed away at his home in New York City May 20, 1931. His death, it is believed, was due almost directly to an automobile accident which occurred while he was en route to Florida in March. Primarily a financier and promoter of innumerable engineering and philanthropic projects, Dr. Adams was born in Boston, Mass. April 9, 1846. From college days on, he has been the recipient of almost countless honors; his degrees (B. S. 1864, M. S. 1897, LL.D. 1906 and M. A. 1908) were followed by titles of both national and international merit including the Royal Order of the Crown of Prussia (1909) and the Médaille de Réconnaissance of the French Republic (1921). In 1926 he received the John Fritz Medal "for great achievement as an engineer, financier and scientist;" he was patron and Life Member of the American Association for the Advancement of Science; patron and Fellow for Life of the American Fine Arts Society; Fellow for Life of the American Geographical Society; and Life Member of the National Geographical Society, the Massachusetts Institute of Technology Alumni Association, the New York Academy of Science, New York Historical Society, Germanistic Society of America, New York Botanical Garden (of which he also was manager and past officer 1912-19), Society of the Sons of the Revolution, New York Geneological and Biographical Society; a Fellow in Perpetuity of the Metropolitan Museum of Art, the Museum of Natural History and the National Academy of Design; a member of the Edison Pioneers; a Fellow and member of the Power Division of the American Society of Civil Engineers; a member of the executive board, engineering division, and electric insulation committee of the National Research Council. Since its inception he has held the chairmanship of the Committee on War Memorial to American Engineers which controlled the building and bestowal of the worldwide famous carillon installed and dedicated at the University of Louvain, Liege, Belgium, July 4, 1928. As a past-officer and director, has included in his activities the promotion of few less than a hundred industrial, educational, and charitable organizations. From 1922 to 1924 he was chairman of the Institute's Edison Medal Committee and from 1916 to the date of his death has represented the Institute on the Engineering Societies' Library Board and in the United Engineering Trustees, Inc. His membership in twenty-seven of the prominent clubs, local and otherwise, including the Engineers Club of New York, the Technology Club (Life Member), Faculty Club of Columbia University, Grolier Club, New York Railroad Club, Lawyers Club, Metropolitan Club, Mendelssohn Glee Club, Economic Club of New York, the Chicago Club and the Adirondack League Club, conveys some intimation of the breadth of application of his activities. Science, art, industry, education, and charity in every community in which he has had his being have benefited by his generosity.

Charles Day (A '02) chairman of the board of Day & Zimmerman, Inc., Philadelphia, Pa., and an expert in plant operation, died at the University Hospital, Philadelphia, May 10, 1931 after an illness of ten days, with which he was stricken a few days subsequent to his return from a trip to North Africa. Philadelphia was his native city; in boyhood he attended the Germantown Academy and in 1899 he was graduated from the department of electrical engineering, University of Pennsylvania. That summer he worked in the engineering department of the National Export Exposition, later associating himself with the Link Belt Engineering Company. As an acknowledged authority on industrial plant equipment and management of public service corporations, he lectured before the Graduate School of Business Administration at Harvard and Columbia universities. At the beginning of the World War he was made trustee of the Emergency Fleet Corporation and during the war served also as a member of a civilian board to investigate the efficiency of the Navy Yards. In the winter of 1917 he attended the war council of the Allies and as one of the Storage Committee of the General Munitions Board he conferred with General Pershing and French officials in an effort to speed the transportation of troops and supplies to Europe. He was appointed by the Secretary of War to the Depot Board. He was engineering advisor to Colonel House, a member of the board of management of Franklin Institute, a trustee of the University of Pennsylvania, and a member of the American Society of Mechanical Engineers; also he was a director of the Pennsylvania Railroad, the Philadelphia Fidelity and Trust Company and the United Gas Improvement Company of which his partner Mr. John E. Zimmerman was president. Socially, his memberships included the Engineers' Club (Philadelphia and New York), the Aero Club of America, the Huntington Valley Club and the Raquette Club. His contributions to technical literature were many and his book "Industrial Plants" has had wide circulation.

Stanley L. B. Lines (M '18) vice-president of the Sangamo Company, Ltd., of Toronto, Canada, died at his home there April 9, 1931. He was born in Shire Newton, England in 1884, and received his early education in English private schools. With Brockie Pell Lamp Company, London, he was an honor pupil for three years and also attended evening classes at the City and Guilds Technical Institution for another three years. After completing an apprenticeship with the British Thomson-Houston Company, he joined the technical staff of the Chamberlain & Hookham Company of England, and as its special representative traveled to almost every known continent, finally establishing and managing the Canadian branch of the company at Toronto. In 1919 with Prof. P. M. Lincoln, under whose patents the work was largely carried on, he organized at Toronto the Lincoln Meter Company, Ltd., (producers of a large line of measuring devices) he himself acting in the capacity of vice-president and manager. In 1930 this company was absorbed by the Sangamo Electric Company of Canada, the company of Mr. Lines' final affiliation. His was a long and noteworthy record with the electrical industry of Canada, conspicuous in conjunction with the Canadian Electrical Association and his work as a member of its meter committee. He was past-president of the Electric Club of Toronto, an Associate Member of the Institution of Electrical

Engineers in England, a member of the Association of Professional Engineers of Ontario and belonged to numerous clubs and technical organizations. He was a survivor of the Lusitania disaster.

W. S. Richmond (A '15) secretary, treasurer, and general manager of the Marseilles Land and Water Power Co., Ottawa, Canada, died April 11, 1931. He was a native of Cheshire, Mass. and 50 years of age. Upon grauadation from the Adams High School in 1901, he immediately entered upon his technical training at Massachusetts Institute of Technology from which he was graduated with the degree of B. S. in civil engineering June, 1905. Early in 1909 he was first assistant to the resident engineer of the United States government determining the efficiencies of generating units of the Niagara Falls Power Company; later that same year he engaged in a similar capacity at Sault Ste. Marie, Michigan, in connection with government tests of plants of Lake Superior Power Company, the Edison Sault Electric Company and the Lake plants in Michigan. In 1914 the United States government engaged him as resident engineer in full charge of determining efficiencies of generating units in the plants of the Hydraulic Power Company at Niagara Falls. More recently he was civil engineer with the United States Lake Survey (of the War Department) in charge of government surveys of harbors on the east coast of Lake Michigan.

Clark E. Baker (A '21), a member of the transportation engineering department of the General Electric Company at Erie, Pa., and for a number of years a resident of Schenectady, died at his home in Erie on May 11 after a short illness. He was a graduate of California Institute of Technology, Pasadena, in 1917 and went to Schenectady in June of that year on the student training course. In September he entered the army engineering corps and continued in service until March, 1919.

Resuming work at Schenectady he was transferred in August, 1919, to the company's railway engineering department, specializing on substation equipment applications. In September, 1929, he moved to Erie with the department and was placed in charge of the substation section.

He was born at Paw Paw, Illinois, December 19, 1894, but the family early removed to Santa Ana, California, where both parents now are living. He is survived by his wife, Myrtle Van Allen, and two children, a boy of 7 and a girl of 5. He was active in American Institute of Electric Engineers affairs, serving on committees and contributing to the proceedings. Interment was at Santa Ana, California.

Robert McRae Wilson (A '24) electrical engineer of the General Electric Company, Bloomfield, N. J. and resident of Montclair, N. J., died suddenly April 24, 1931, while in Savannah, Ga. on a motor trip. He was a native of Beaufort, S. C., but his technical education was acquired in the State of New York—two years at City College of New York and the regular four-year course at Cornell University from which he was graduated in 1896. The following year he engaged with the Hyer Sheehan Electric Motor Company of Newburgh, N. Y., for eighteen months general engineering and estimating work; then he joined the Sprague Electric Company at Bloomfield, N. J. The next year he became instructor in electrical engineering at Lehigh University, but at the end of one semester returned to the Sprague company and remained with it after it became the Sprague Electric Works of the General Electric Company; later the Bloomfield Works of that company. Mr. Wilson's term of service, extending over a period of thirty years, included considerable specialized work on d-c. motor and generator design.

Edward B. Plenge (A '22) electrical engineer of the waterwheel generator section of the a-c. engineering department of the General Electric Company, Schenectady, N. Y., died April 3, 1931 due to injuries sustained by being struck by an automobile. He was born in Charleston, S. C. in 1886, and was graduated from Clemson College in 1907, having completed its course in electrical engineering. In August of that year he engaged in the G. E. Test Course at the Schenectady works, and in October 1909 joined the a-c. engineering department of the company, where he has remained in continuous service. He has had charge of the design work on waterwheel-driven generators for a number of years during a period when General Electric achievement in this field included generators for the Conowingo Dam, the 65,000-kw. units at Niagara Falls, and the 77,500-kw. units for the U. S. S. R. Mr. Plenge's home was in Scotia, New York, where he was held in high esteem by both his professional and personal friends. He was a member of the Edison Club and of the Schenectady Country Club.

McKee Duncan (A '14) consulting engineer of Duncan, Young & Company, New York City, met with sudden death on the public golf course at Van Cortlandt Park there. He was 43 years of age. In 1910 the degree of B. S. was conferred upon him by Columbia University; later in that same year he went to Europe for graduate work in physical chemistry at the University of Leipzig. Returning to the United States in 1911, he continued the study of physical chemistry at the University of Wisconsin. His early commercial connection brought him in close association with Dr. Louis Duncan as a member of the firm of Duncan, Young & Pressey, Inc., predecessors of the company of his last affiliation, and was heartily endorsed by him for membership in the Institute after a friendship which had endured for over twenty years.

Joseph T. Blondin (A '18) director of the Revue Générale de l'Electricite, France, passed away at the home of his son in Paris, April 21, 1931. He was in the 68th year of his age. Born in Dieppe, he led a most active professional career, held in high esteem by his countrymen. He was well-known as an electrical engineer, and bore the honorary titles of Officer d'Academie, Officer de l'Instructions Publique and Chevalier du Merite Agricole. He was also professor of mathematics and professor of physics at several of the representative universities of France, including Orleans and the College of Rollins. Many of the French technical publications were issued under his directorate.

Addresses Wanted

A list of members whose mail has been returned by the postal authorities is given below, with the address as it now appears on the Institute records. Any member knowing of corrections to these addresses will kindly communicate them at once to the office of the secretary at 33 West 39th St., New York, N. Y.

Collinot, Marcel A., 88 Sherman Ave., Newark, N. J.

DiLucci, A., Box 1051, Chicago, Ill.

Duane, George B., Otis Elevator Co., Yonkers, N. Y.

Muncy, V. E., Ohio Mechanics Institute, Cincinnati, Ohio.

O'Shea, V., Jr., 115 Broadway, New York, N. Y.

Tung, C. T., c/o Stone & Webster Engg. Corp., Hopewell, Va.

Local Meetings

Florida Section Organized

At its meeting held on January 28, 1931, the Institute's board of directors authorized the formation of the Florida Section to cover the entire state.

This Section held an organization meeting March 27th, at which the following officers were elected: Prof. Joseph Weil (A '24) chairman; C. S. Hammatt (M '23) vice-chairman; R. P. Smith, secretary-treasurer; H. N. Fairbanks, member executive committee.

Student Convention at Rose Polytechnic Institute

The annual student convention of the Branches at Purdue University, University of Illinois, and Rose Polytechnic Institute was held at Rose Polytechnic Institute April 18, 1931; total attendance 120.

The afternoon was devoted to an inspection trip to the Dresser plant of the Indiana Electric Corporation, and the mine operating in conjunction with it. Addresses of the evening were:

Railway Electrification, by W. D. Bearce (M '30), General Electric Company.

The Operation of Large Electric Power Plants, by L. B. Andrus (F '19) president, Indiana Electric Corporation.

North Central District Holds Student Activities Conference

The fifth annual conference on student activities in District No. 6 was held at the University of North Dakota (Grand Forks) on April 17-18, 1931. Of the nine schools in the District, eight were represented by both counselors and chairmen.

Friday Evening

In the absence of Thomas F. Kane president of the University of North Dakota, the address of welcome was given by Dr. William G. Bek, dean of the junior division. Dean H. S. Evans (M '09) vice-president, District No. 6, responded for the delegates and then presided during the presentation of the following program:

Report of summer convention of the A. I E. E. held June 1930 at Toronto, Ont., Canada, by Prof. G. H. Sechrist (A '20) counselor, University of Wyoming Branch, and chairman of the district committee on student activities.

Personal Qualities which a Branch Chairman Should Develop to be a Successful Leader of His Branch, Prof. W. C. DuVall (M '20) counselor, University of Colorado Branch, Prof. F. W. Norris (M '26) counselor, University of Nebraska Branch.

Formal discussion presented by Neil Sanders, chairman, University of Wyoming Branch.

The Effect of Electricity Upon the Human Body, by R. B. Witmer, Asst. Prof. of Physics, University of North Dakota.

After the completion of the program the business meeting of the counselors and an informal meeting of the Branch chairmen were held in parallel session. Prof. G. H. Sechrist (A '20) chairman, District committee on student activities, presided at the former.

The counselors decided that the sixth annual conference will be held in the spring of 1932 at the University of Denver.

Prof. H. F. Rice (A '21) counselor, University of North Dakota Branch was elected chairman of the committee on student activities for the ensuing year and delegate to the summer convention at Asheville. Prof. D. R. Jenkins (A '16) counselor, University of North Dakota Branch was elected alternate delegate.

Saturday Morning

Vice-president Evans presided.

Should Qualifications for the Grade of Enrolled Students be Established?, by Prof. B. B. Brackett, counselor, University of South Dakota Branch.

Formal discussion presented by B. J. Shields, chairman, University of North Dakota Branch.

Should Attendance at Student Branch Meetings be Made Compulsory and Credit Given for this Work?, by Prof. H. F. Rice, counselor, University of North Dakota Branch, presented by Charles C. Libby.

Formal discussion presented by A. Steponaitis, University of South Dakota Branch.

What the Prospective Employer Looks for in the Engineering Graduate, by Prof. H. S. Rush (M' 30) counselor, North Dakota Agricultural College Branch.

Formal discussion presented by Almon Bjerke, chairman, South Dakota State School of Mines Branch.

What Can the Institute do Through Its Branches to Inform High School Students of the Opportunities and Need for Trained Electrical Engineers, by Prof. J. O. Kammerman (M' 20) counselor, South Dakota State School of Mines Branch.

Formal discussions presented by R. M. Partington, chairman, University of Colorado Branch, and H. H. Ward, chairman, University of Denver Branch.

How Best May the Branch Serve in the Development of Its Members as Engineers?, by Prof. R. E. Nyswander (M '22) counselor, University of Denver Branch.

Formal discussions presented by Phil Ehrenhard, chairman, University of Nebraska Branch, and C. E. Bryant.

San Francisco Section Meets with Branches

The annual joint meeting of the San Francisco Section and the student Branches at the University of California, University of Santa Clara, and Stanford University was held on the Stanford campus April 17, 1931; attendance 165.

In the afternoon visits to engineering laboratories and shops were concluded by a demonstration of high-voltage flashover at the Ryan High-Voltage Laboratory.

During the dinner held in Stanford Union, entertainment was furnished by the Branches; an address of welcome was given by Theodore J. Hoover, dean of the School of Engineering, and Dr. Harris J. Ryan (F '23) executive head of the department of electrical engineering and past-president of the A. I. E. E., spoke on the establishment of the student Branches of the Institute.

The evening's technical program presented by students was as follows:

Vacuum-Tube Voltage Regulators, by Edwin W. Palmrose, senior, University of California.

Development of Television, by Charles Harvey and Lionel Thorpe, juniors, University of Santa Clara.

Corona and Transmission-Line Surges, by Hugh H. Skilling, graduate student, Stanford University.

The prize of one year's Associate's dues in the Institute was awarded to H. H. Skilling.

Past Section Meetings

Baltimore

The Holtwood Hydraulic Laboratory and Its Contribution to the Design of the Safe Harbor Development, by G. W. Spaulding, Pennsylvania Water and Power Co.;

Construction of the Safe Harbor Development, by C. W. Black, The Arundel Corp. Inspection trip to the Safe Harbor Hydroelectric Project. Joint meeting with the Engineering Societies of Baltimore. April 23. Attendance 300.

Birmingham

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of

Virginia, and vice-president, District No. 4, A. I. E. E. March 20. Attendance 7.

Boston

PERFORMANCE OF HIGH-TENSION CABLE, by F. Malcolm Farmer, Electrical Testing Laboratories. Buffet supper served prior to the meeting. April 24. Attendance 100.

Cleveland

HUMAN RELATIONS IN INDUSTRY, by Whiting Williams. E. C. Stone, The Philadelphia Co., and vice-president, District No. 2, A. I. E. E. gave a short talk on Institute activities. Two papers were presented by students as follows:

THE CATHODE-RAY OSCILLOGRAPH, by J. F. Matyas;

BRIDGE-CIRCUIT CONTROL OF THYRATRON TUBES, by I. J. Rand. Joint meeting with the Case School of Applied Science Branch. April 15. Attendance 101.

Columbus

AUDIBLE LIGHT AND VISIBLE SOUND, by John B. Taylor, General Electric Co. Demonstrations. March 27. Attendance 250.

Connecticut

Talks on electrical control of temperature by O. H. Hunt, T. F. Herring, J. J. Carney, and P. A. Borden, all of the Bristol Company's engineering staff. April 14. Attendance 50.

Dallas

MODERN DEVELOPMENTS IN COMMUNICATIONS, by S. P. Grace, assistant vice-president, Bell Telephone Laboratories, Inc. Illustrated. Joint meeting with the Dallas Electric Club. April 13. Attendance 340.

Denver

Annual College Night at which the following papers were presented by students:

NEW IDEAS FOR HIGH-VOLTAGE CIRCUIT BREAKERS, by Charles A. Church and Neil R. Damon, University of Colorado;

THE LIFE OF FARADAY, by Oscar Bear, Colorado Agricultural College;

VARIATION WITH TEMPERATURE OF THE MAGNETIC PROPERTIES OF IRON AND NICKEL, by Harry H. Ward and Gerald O. Cannon, University of Denver. April 24. Attendance 110.

Detroit-Ann Arbor

THE 1,000-DEG. TURBINE, by Paul W. Thompson, Detroit Edison Co. There was an inspection of the new Delray Power House and the 1,000-deg. turbine. April 21. Attendance 250.

Erie

HOBOKEN ELECTRIFICATION OF D. L. & W. RAILROAD, by Edward L. Moreland, Jackson & Moreland. Dinner preceded the meeting. April 21. Attendance 150.

Fort Wayne

SATURATED REACTOR AND CAPACITOR CIRCUITS, by C. M. Summers and L. F. Hemphill, both of the General Electric Co. April 16. Attendance 60.

Indianapolis-Lafayette

RESEARCH AND INDUSTRY, by E. L. Manning, General Electric Co. Demonstration of the thyratron tube. April 10. Attendance 280.

Iowa

TREND IN THE DESIGN OF PRINCIPAL ELECTRICAL FEATURES OF STEAM POWER STATIONS, SUBSTATIONS, AND TRANSMISSION LINES, by H. W. Eales, Byllesby Engineering and Management Corp. Illustrated with lantern slides. April 16. Attendance 35.

Ithaca

SOME RECENT DEVELOPMENTS IN RADIO RECEIVER TUBES, by Walter R. Jones, Sylvania Products Co. March 20. Attendance 50.

Lehigh Valley

THE HOME LIGHTING STORY, by Lilliam E. Eddy, Edison Lamp Works;

WHEN ELECTRICITY IS THE MASTER SERVANT, by Clara Zillessen, Philadelphia Electric Co. Illustrated. Ladies' Night held at the Hotel Americus, Allentown, Pa.

Los Angeles

Discussion and demonstration of sound-recording and reproduction as practised in the motion picture industry. Speakers: R. H. Townsend, RCA Photophone Company, H. C. Silent and J. H. Frayne, Electrical Research Products, Inc. Illustrated by lantern slides and talking motion pictures. April 14. Attendance 426.

Louisville

Inspection trip through the Axton-Fisher Tobacco Co. May 8. Attendance 55.

Lynn

CHANGING VIEWS OF THE NATURE OF MATTER, by Saul Dushman, General Electric Co. March 18. Attendance 450.

The twentieth annual banquet. March 28. Attendance 460.

Discussion on RADIO TUBES, by O. H. Biggs, A. C. Rockwood, G. D. O'Neil, all of the Hygrade Lamp Co. April 8. Attendance 300.

Madison

MODERN ELECTROPLATING, by J. G. Zimmerman, Burgess Laboratories;

CHROMIUM PLATING—THE ELECTROPLATE THAT IS DIFFERENT, by Professor O. P. Watts, University of Wisconsin. Inspection trip to the Scanlan-Morris Company's plant. April 29. Attendance 27.

Mexico

ERICSSEN SYSTEM OF LONG-DISTANCE TELEPHONY, by Helge F. Rest, Ericssen Company. April 14. Attendance 22.

Minnesota

FACTORS AFFECTING NOISE INDUCTION BETWEEN POWER AND TELEPHONE CIRCUITS, by F. R. Kappel, Northwestern Bell Telephone Co. April 29. Attendance 150.

Niagara Frontier

ART IN INDUSTRY, by D. R. Dohner, Westinghouse Elec. & Mfg. Co.;

QUICK-TRIP GRAPHIC METERS AND THEIR APPLICATION, by D. J. Angus, Esterline-Angus Co. Illustrated. Election of officers as follows: R. W. Graham, chairman; E. S. Bundy, vice-chairman; G. W. Eighmy, secretary-treasurer, H. B. Vidal and G. W. Brooks, members executive committee. April 17. Attendance 50.

Oklahoma City

TELEGRAPHIC PILOT-WIRE RELAY SYSTEM, by J. D. Browder, Oklahoma Gas & Electric Co. and E. B. Jennings, Southwestern Bell Telephone Co. April 29. Attendance 61.

Pittsburgh

ELECTRIC-ARC FURNACE INSTALLATIONS, by Samuel Arnold, American Bridge Co.;

ARC-FURNACE CONTROL, by C. C. Levy, Westinghouse Elec. & Mfg. Co. Illustrated with lantern slides. Joint meeting with the Engineers' Society of Western Pennsylvania. April 14. Attendance 93.

Philadelphia

SPEED, UNEMPLOYMENT, AND PROGRESS, by William McClellan, Stone & Webster Engg. Corp. April 13. Attendance 150.

Portland

APPLICATION OF VACUUM TUBES, by A. W. Copley, Westinghouse Elec. & Mfg. Co. Demonstrated. Joint meeting with the N. E. L. A. March 16. Attendance 96.

WAVES OR PARTICLES, by A. A. Knowlton, Reed College. Joint meeting with the N. E. L. A. April 21. Attendance 90.

Providence

MAGIC TUBES, by Prof. F. N. Tompkins, Brown University. Dinner in honor of the speaker preceded the meeting. March 10. Attendance 220.

Rochester

New Developments in Vacuum Tubes, by Eugene W. Ritter, RCA Radiotron Co. Joint meeting with the I. R. E. April 16. Attendance 97.

In Years to Come, by James G. Harbord, Radio Corporation of America. Tenth annual dinner of the engineering societies of Rochester. April 18, Attendance 395.

St. Louis

Introduction of Higher Speed into Transmission Line Protection, by W. E. Winterhalter, General Electric Co. Election of officers for term 1931-32 as follows: C. H. Kraft, chairman; F. B. Wipperman, vice-chairman; C. H. Lankford, secretary. April 15. Attendance 60.

San Antonio

Lightning and Lightning Protection, by P. F. Squier, Westinghouse Elec. & Mfg. Co. Illustrated. April 13. Attendance 32.

Sharon

Hon. Frank Crowther, U. S. Congressman from New York, discussed the problems presented to the last Congress. Before the meeting there was an inspection trip through the McDonald Plant of the Carnegie Steel Co. Joint meeting with the Association of Iron and Steel Electrical Engineers. April 15. Attendance 310.

The Contribution of Telephone Research to Talking Motion Pictures, by J. O. Perrine, American Telephone & Telegraph Co. Illustrated. May 5. Attendance 240.

Spokane

A Progress Report on a Short Circuit Model of the Washington Water Power Company System, by Clarence L. Holmes, State College of Washington;

Short-Circuit Transients In Synchronous Generators, by Robert Pennoyer, University of Idaho;

Fundamentals of Carrier Telephony, by Loren A. Traub, Home Telephone & Telegraph Co. Dinner preceded the meeting. April 24. Attendance 46.

Springfield

Grounding the Neutral, by W. W. Lewis, General Electric Co. Illustrated. March 19. Attendance 56.

Electrotherapy, by William Bierman, president, N. Y. Physical Therapy Society. April 13. Attendance 52.

Toledo

System Regulation, by T. J. Nolan, Toledo Edison Co.;

Storage Batteries, by W. E. Dunn, Electric Storage Battery Co. Illustrated. April 17. Attendance 45.

Toronto

Interesting Developments and Problems in Central Station Engineering, by R. E. Powers, Westinghouse Elec. & Mfg. Co. Joint meeting with Engineering Institute of Canada. April 24. Attendance 250.

Annual meeting. French Faience, by C. H. Mitchell, University of Toronto. Illustrated. Election of officers as follows: T. W. Eadie, chairman; G. D. Floyd, secretary. May 1. Attendance 43.

Utah

Miracles from the House of Magic, by H. T. Plumb, General Electric Co. Inspection of the laboratories at University of Utah followed by dinner. April 9. Attendance 470.

Vancouver

Starting Conditions in Synchronous Machines and an Analysis of the Synchronous-Induction Motor, by H. Vickers, University of British Columbia. April 6. Attendance 33.

Inspection of Ruskin Hydroelectric Development of the British Columbia Electric Railway Co. April 25. Attendance 64.

General Developments in the Bell Telephone Laboratories, by C. C. Pettet, Northern Electric Co. May 4. Attendance 41.

Washington

Lightning and Lightning Arresters, by M. G. Lloyd, Bureau of Standards. Orville S. Peters was presented with the John Scott Award for the invention and development of the electric telemeter. April 14. Attendance 94.

Worcester

Copper from Mine to Consumer, by William H. Bassett, Jr., Anaconda Wire & Cable Co. Joint meeting with the A. S. M. E.

Fused Quartz, by A. L. Ellis, General Electric Co. May 12. Attendance 40.

Past Branch Meetings

Alabama Polytechnic Institute

Election of officers as follows: W. H. Mimns, chairman; T. N. Pyke, vice-chairman; G. F. Fuker, secretary. April 23. Attendance 17.

University of Alabama

Business meeting. April 27. Attendance 15.

University of Arizona

X-Rays and Their Application, by Paul F. Hawley, student. April 10. Attendance 6.

University of Arkansas

Demonstration of a color organ was given by Professor Wesley Roberds, Physics Dept. April 23. Attendance 22.

Armour Institute of Technology

Film—"The Single Ridge." May 1. Attendance 51.

Polytechnic Institute of Brooklyn

Electrons and Sub-Electrons, by Dr. Ernst Weber. April 23. Attendance 42

California Institute of Technology

Power Systems of Germany, England, and France, by Professor W. T. Ryan, University of Minnesota. April 16. Attendance 35.

University of California

Russian Five Year Plan, by Robert Sibley, University of California Alumni Association. Joint meeting with the A. S. M. E. Branch. April 8. Attendance 55.

Carnegie Institute of Technology

Sound Motion Pictures, by Carl Long, student;

Underground Cables, by Thomas Zima, student. Election of officers as follows: Walter B. Wigton, chairman; H. A. Wagner, vice-chairman; F. A. Lennberg, secretary; S. J. Myers, treasurer. April 15. Attendance 22.

University of Cincinnati

Life of Joseph Henry, by D. Michael, student. Illustrated lecture on Electric Ship Propulsion. Election of officers as follows: W. Kock, chairman; H. Koerber, vice-chairman; Mr. Schmidt, secretary; Mr. Manning, treasurer. April 21. Attendance 23.

Clarkson College of Technology

Inspection trip to the sawmill of the Elliott Hardwood Co., Inc., at Potsdam. April 8. Attendance 12.

Colorado State Agricultural College

Inspection trip to the Valmont electrical plant of the Public Service Co. of Colorado. April 24. Attendance 11.

University of Colorado

New Developments in Engineering, by Wm. Trudgian, Westinghouse Electric & Mfg. Co. Film—"Westinghouse Steam Turbines." April 1. Attendance 38.

Annual College Night held jointly with the Denver Section. (For complete report see "Past Section Meetings.")

Cornell University

Talks on the life of Faraday by four students. Election of officers as follows: Randall A. Smith, chairman; Wm. S. Bachman, secretary-treasurer. April 22. Attendance 23.

Drexel Institute

POTENTIOMETER PYROMETER, by Fred C. Haish, student. April 21. Attendance 34.

An explanation and description of the Reading R. R. suburban electrification and Wayne Junction substation construction was given by S. I. Croney, student. May 5. Attendance 10.

Duke University

COURIER SYSTEMS USED IN TELEPHONE COMMUNICATIONS OF POWER COMPANIES, by S. G. Flack, student. Election of officers as follows: S. G. Flack, chairman; A. L. de Bruyne, vice-chairman; J. A. Womack, secretary-treasurer. May 5. Attendance 15.

Georgia School of Technology

LIGHTING, by Mr. Horton, General Electric Co. April 8. Attendance 113.

Harvard University

ENGINEERING STUDENTS AND THE MANAGEMENT OF MEN, by Professor E. D. Smith, Yale University. April 24. Attendance 30.

University of Iowa

Four reels of motion pictures on telephone communications were shown. April 15. Attendance 42.

University of Florida

LIGHTING DESIGN, by John W. Wilson, student. April 13. Attendance 23.

Election of officers as follows: R. E. Walker, chairman; J. C. Huffer, vice-chairman; L. P. Barnett, secretary-treasurer. April 20. Attendance 21.

Kansas State College

THE SUCCESSFUL ENGINEER, by Professor L. M. Jorgenson. April 9. Attendance 67.

The same program was presented at the evening meeting. April 9. Attendance 41.

THE ENGINEERING FIELD, by H. S. Kilby, Kansas Power Co. Film—"The Benefactor." April 23. Attendance 40.

The same program was presented at the evening meeting. April 23. Attendance 70.

THE DESIGN OF TELEPHONE OUTSIDE PLANTS, by E. C. Kuhlman, Southwestern Bell Telephone Co. May 7. Attendance 73.

The same program was presented at the evening meeting. May 7. Attendance 40.

University of Kansas

Banquet. Attendance 146.

LIFE OF MICHAEL FARADAY, by Charles Brecheisen, student;

LIFE OF JOSEPH HENRY, by Clifford Hamel, student. The Branch was presented with the Sigma Tau cup for the best exhibits in the engineering exposition. May 7. Attendance 47.

Lafayette College

Business meeting. May 2. Attendance 25.

Lewis Institute

Description of the electrification of the suburban division of the Illinois Central Railroad Co., by C. H. Mottier, of that company. April 3. Attendance 151.

University of Louisville

LIFE OF JOSEPH HENRY, by Mr. Friedman, student;

LIFE OF FARADAY, by Mr. Knoop, student. Mr. Cook, student, reviewed the achievements of 1930. March 20. Attendance 15.

University of Maine

RADIO, by Walter J. Creamer, student. April 9. Attendance 22.

Election of officers as follows: R. E. Young, chairman; Gerald Frost, vice-chairman; Roland J. Tibbetts, secretary; Thomas Morrison, treasurer. April 21. Attendance 16.

VACUUM TUBES AND THEIR INDUSTRIAL APPLICATIONS, by Oliver Ajer, General Electric Co. Demonstration of the operation of the photoelectric cell and the thyratron. April 23. Attendance 160.

Marquette University

Executive board meeting. March 26. Attendance 7.

SWITCHES AND SWITCHING, by J. D. Greensward, Allis-Chalmers Co.;

PERSONALITY IN ENGINEERING, by H. S. Day, Wisconsin Telephone Co. Annual banquet. April 9. Attendance 50.

Massachusetts Institute of Technology

THE PIEZOELECTRIC OSCILLATOR IN THE POWER INDUSTRY, by B. H. Buckingham; student;

RADIO IN AERONAUTICS, by J. G. Ritchey, student. April 14. Attendance 50.

Michigan College of Mining and Technology

FARADAY AND HIS EARLY EXPERIMENTS, by Oscar Hane, student;

THE EARLY HISTORY OF ELECTRICITY, by William Keyes, student. March 25. Attendance 15.

Michigan State College

Demonstration and explanation of the control device called the "Telemat," by W. H. Bliss, instructor. April 14. Attendance 23.

Talks on the life and work of Faraday and Henry, by E. Moore and J. Young, students. Election of officers as follows: Edwin W. Moore, chairman; John Young, vice-chairman; Webster Bowler, secretary-treasurer. April 28. Attendance 24.

University of Michigan

EXPERIENCES WITH THE DETROIT EDISON CO., by William S. Thomas, student. April 29. Attendance 28.

School of Engineering of Milwaukee

SUBSTATIONS AND SUBSTATION METERING EQUIPMENT, by William Duhn, instructor;

VACUUM TUBES AND THEIR USE IN MEDICINE, by Wm. P. Gainer, Branch chairman. Film—"The Single Ridge." April 8. Attendance 45.

Missouri School of Mines and Metallurgy

THE APPLICATION OF THE PHOTOELECTRIC CELL, by M. R. James, student;

HYDROELECTRIC DEVELOPMENTS, by Professor I. H. Lovett, counselor. April 15. Attendance 24.

Inspection trip to the Bagnell Dam. April 18. Attendance 43.

Six films shown as follows: "Telephoto Equipment," "Television," "Electric Heat in Industry," "Induction Voltage Regulators," "Oil Circuit Breakers," and "The Automatic Substation." April 22. Attendance 24.

Montana State College

Banquet given in honor of Dean H. V. Carpenter, University of Washington, and vice-president, District No. 9, at which he delivered an address entitled CONTINUITY OF SERVICE. April 9. Attendance 39.

MAN AND HIS MACHINES, by Dean H. V. Carpenter. April 9. Attendance 164.

ELECTRIC COMMUNICATION AND THE NEW YORK STOCK EXCHANGE, taken from ELECTRICAL ENGINEERING, presented by C. G. Anderson, student;

CRACKING OIL BY ELECTRICITY, taken from ELECTRICAL ENGINEERING, presented by Eric N. Blannin, student;

INSPECTION OF ARC WELDS, by Edgar Dolum, student;

TWO ELEVATORS IN ONE SHAFT, taken from *Electric Journal*, presented by Leonard Estey, student. April 16. Attendance 125.

Election of officers as follows: Homer Lambdin, chairman; Jean Smith, vice-chairman; Wesley Funk, secretary; William Scheele, treasurer. April 21. Attendance 30.

PRIVATE-WIRE TELEGRAPH SERVICE, taken from ELECTRICAL ENGINEERING, presented by James Graybeal, student;

MAINTENANCE OF DISTRIBUTION SYSTEMS, by Arthur W. Buckley, student;

RAILROADS VS. TRANSMISSION LINES, taken from ELECTRICAL ENGINEERING, presented by Wesley Funk. April 23. Attendance 120.

VENTILATING ELECTRICAL GALLERIES, taken from *Electrical World*, presented by Curtis Hanson, student;

RECENT USES AND DEVELOPMENTS OF ELECTRICITY IN TRANSPORTATION, by Armin J. Hill, student;

RADIO BEACON GUIDES PLANES, by Homer Lambdin, student. April 30. Attendance 114.

Inspection trip to the Anaconda Copper Mining Company; Morony, Volta, Rainbow, and Black Eagle power plants of the Montana Power Co.; Claude Neon Sign Works; Automatic telephone exchange of the Mountain States Tel. & Tel. Co.; and radio station KFBB. May 4-6. Attendance 29.

ANALYSIS OF RADIO INTERFERENCE, by W. H. Bato, student;

TREATING REWOUND MOTORS, by Carl Wall, student;

CURRENT COLLECTION IN HYDROGEN ATMOSPHERE, by Jean Smith, student. May 6. Attendance 77.

University of Nevada

ENGINEERING ECONOMICS, by J. Hough, student;

NEW DEVELOPMENTS IN SYNCHRONOUS MOTORS, by Clarence Jones, student. April 4. Attendance 13.

THE USE OF HYDROGEN IN ROTATING ELECTRICAL APPARATUS AS A COOLING MEDIUM, by E. H. Tucker, student. April 15. Attendance 24.

Newark College of Engineering

MERCURY ARC RECTIFICATION, by Paul Dumont, General Electric Co. Election of officers as follows: E. Olsta, president; J. G. Woehling, vice-president; M. Barker, treasurer. April 20. Attendance 25.

University of New Hampshire

THE PROBLEMS OF TELEPHONE TRANSMISSION, by O. W. Eshbach, American Tel. & Tel. Co. April 10. Attendance 103.

VACUUM TUBES, by Oliver Ajer, General Electric Co. Demonstrations. April 21. Attendance 83.

College of the City of New York

Eighth annual dinner. April 9. Attendance 112.

ELECTRIC DRIVE OF SHIPS, by Frank V. Smith, General Electric Co. April 16. Attendance 20.

North Carolina State College

Election of officers as follows: G. E. Ritchie, chairman; J. W. Southerland, vice-chairman; L. C. Hubbard, secretary. April 14. Attendance 28.

RADIO FREQUENCY AMPLIFIERS, by W. S. Smith, student. May 12. Attendance 21.

University of North Carolina

RADIO APPLICATIONS, by R. V. Whitener, student. Election of officers as follows: D. J. Thurston, Jr., chairman; R. C. Cadmus, vice-chairman; Lloyd Swain, treasurer; Sam Barham, secretary. April 23. Attendance 41.

North Dakota State College

Election of officers as follows: Clarence Bryant, chairman; Fred Payne, vice-chairman; Ralph Simenson, secretary-treasurer. April 13. Attendance 13.

LIFE OF STEINMETZ, by Andrew Fritch, student. Film—"Electric Welding." Joint meeting with A. S. M. E. April 16. Attendance 66.

Film—"Dynamic America." Joint meeting with A. S. M. E. and College Engineers' Club. April 30. Attendance 57.

University of North Dakota

Film—"The General Electric Test Course." April 29. Attendance 15.

University of Notre Dame

SUBSTATION DESIGN, by E. P. Kreimer, Indiana Michigan Electric Co. Patrick Murray, student, presented the regular engineering news review. April 13. Attendance 46.

APPLICATION OF ELECTRICITY TO METALLURGY, by Edward G. Mahin, chemistry dept.;

THE MECHANICAL LARYNX, by Charles Podlaski, student. Patrick Murray, student, presented the engineering news review. Election of officers as follows: Hugh Ball, chairman; J. Andres, vice-chairman; F. A. Consolati, secretary; L. R. Rohlof, treasurer. April 27. Attendance 56.

Oklahoma A. & M. College

POWER DISTRIBUTION IN CITY LIMITS, by V. A. Pendelton, Oklahoma Gas & Electric Co. Election of officers as follows: Joe Hutchinson, chairman; L. C. Hanan, vice-chairman; Clyde Benson, secretary. April 24. Attendance 40.

Oregon State College

ENGINEERING PRACTISE, by E. D. Searing, Portland General Electric Co. April 30. Attendance 33.

Pennsylvania State College

COLLEGE ILLUMINATION, by Professor D. L. Markle. April 22. Attendance 14.

Pratt Institute

Films—"Conowingo" and "Steam Turbine with a Solid Rotor." April 15. Attendance 23.

Mr. Muldaur, National Fire Underwriters' Laboratories, spoke on the testing and setting of standards for mechanical and electrical equipment, and also gave a brief outline of the development of the association and its uses to the public. April 23. Attendance 150.

Purdue University

HISTORY OF MICHAEL FARADAY'S LIFE, by M. F. Droege, student;

EXPERIMENTS BY MICHAEL FARADAY, by Paul E. Duff, student. W. P. Hallstein and C. C. Fisher, students, gave a demonstration on the operation of a tesla coil. April 28. Attendance 100.

Rhode Island State College

Election of officers as follows: Leon C. Breault, chairman; Byron A. Porter, vice-chairman; Lloyd E. Crandall, Secretary-Treasurer. April 15. Attendance 15.

Rice Institute

TELEVISION, by Mr. Kennedy, student. April 15. Attendance 20.

University of Santa Clara

Election of officers as follows: Lionel W. Thorpe, chairman; John Pecharich, vice-chairman; Thomas Eberhard, secretary-treasurer. April 30. Attendance 21.

University of South Carolina

Business meeting. April 13. Attendance 13.

THE ENGINEER AND HIS CONNECTION WITH SANITATION, by Col. A. E. Legare, supervisor, Dept. of Health. April 20. Attendance 31.

MICHAEL FARADAY, by L. E. Rankin, student;

CHARLES P. STEINMETZ, by C. Urquhart, student. April 27. Attendance 35.

South Dakota State School of Mines

Professor J. O. Kammerman, counselor, Almon Bjerke, Branch secretary, and Charles Laws, Branch chairman, gave reports of the fifth annual conference of student Branches of District No. 6. April 22. Attendance 36.

Stevens Institute of Technology

SUBMARINES, by R. C. Welles, student. April 16. Attendance 25.

Syracuse University

BUSBAR STRESSES, by Oliver Bigsby and Edwin Hinchliffe, students;

SCOTT CONNECTION FOR AUTOTRANSFORMERS, by Lyndon Depew and W. Kleppinger, students. April 17. Attendance 25.

University of Texas

Inspection of the electrical equipment of the Norwood Building, Littlefield

Building, and Austin Power Plant. April 9. Attendance 18.

University of Utah

Election of officers as follows: Richard C. Hansen, chairman; Philip J. Elsey, vice-chairman; W. S. Nishiyama, secretary-treasurer. April 21. Attendance 37.

University of Vermont

Hydrogen Cooling of Rotating Electrical Machinery, by E. J. Mercier, student. April 14. Attendance 22.

Films—"A Concrete Example," "The Telephone Repeater," "Something About Switchboards," and "The World's Telephone Workshop." April 21. Attendance 40.

Election of officers as follows: Donald E. Child, chairman; C. B. Cross, vice-chairman; Robert A. Hyde, secretary-treasurer. April 28. Attendance 24.

Virginia Military Institute

Television, by R. P. Sledge, student;

A Floating Power Plant, by J. C. Shell, student;

Future of Electricity, by H. J. Geiger, student. April 18. Attendance 50.

Virginia Polytechnic Institute

Some Aspects of the Scientific Work of Thomas Jefferson, by Professor W. S. Rodman, University of Virginia, and vice-president, District No. 4, A. I. E. E. May 5. Attendance 51.

University of Virginia

The History and Development of the Telephone, by B. G. Switzer, student. April 7. Attendance 17.

University of Washington

Television, by Carl Johnson, student. April 9. Attendance 13.

"Ruby" the Next Development of the Skagit, by J. D. Ross, former Superintendent of Lighting, City of Seattle. April 16. Attendance 213.

Washington State College

Direct Coupled Amplifiers, Their Construction and Use, by L. N. Hatfield, Branch chairman. May 1. Attendance 22.

Washington University

Election of officers as follows: D. A. Fischer, president; Charles L. Cline, vice-president; Ernest A. Wolff, secretary-treasurer. April 30. Attendance 16.

West Virginia University

The following talks given by students were based on a recent inspection trip:

Westinghouse High Voltage Laboratory, by H. O. Webb;

H. J. Heinz Co., by J. R. Nottingham;

American Bridge Co., by J. E. Newcomer;

Motors for the P. R. R. Electrification, by C. Malone;

New Power Plant in South Carolina, by H. V. Locker;

Pittsburgh Transformer Works, by F. E. Watson. April 21. Attendance 32.

The following talks given by students were based on a recent inspection trip:

Jones & Laughlin Steel Corp., by G. Pride;

Mesta Machine Co., by S. Boone;

Electrical Communication in N. Y. Stock Exchange, by C. DeLancy;

Synchronous Motors for Ship Propulsion, by P. Steenbergen;

Propeller Type of Pumps, by C. Withers;

Bell Telephone Co., by A. Fervier;

Electrification of the Pennsylvania R. R., by W. Unger;

Eddy Currents, by G. Lefevre. April 28. Attendance 32.

University of Wyoming

Election of officers as follows: Neil Sanders, chairman; T. Hance, vice-chairman; Roy Perkins, secretary-treasurer. April 7. Attendance 10.

Life of Faraday, and Circuit Breakers, by Reece Achenbach, student. May 5. Attendance 8.

Yale University

Election of officers as follows: Ludwig B. Hansen, chairman; J. A. Keyser, sreasurer; F. M. Wolff, secretary. May 1. Attendance 16.

Employment Notes

Of the Engineering Societies Employment Service

Positions

Open

ELECTRICAL ENGINEER with experience in designing a-c. and d-c. machines. Apply by letter giving qualifications. Location, vicinity of New York City. W-2753.

YOUNG MAN with training and experience in patent and trade mark law, who would like to work himself into the patent and trade mark problems of a large chemical firm. Apply only by letter. Location, New York. W-2018.

Men

Available

ELECTRICAL ENGINEER with 15 years' experience in design, construction, reports and editorial work. Now engaged on special publishing job; will be available for publicity or editorial work on trade publications. References from leading engineering and publishing firms. B-4022.

1930 TECHNICAL GRADUATE, B. S. in M. E., age 24, single. Five and a half months' experience with conveyer manufacturer. Desires training with some engineering company. Salary secondary. Location, immaterial. Available at once. C-9095.

GRADUATE ELECTRICAL ENGINEER, 35, married. Twelve years' experience of which five as junior executive. Desires position as assistant general executive or in transmission or distribution department, United States. Street railway, power and light utility experience. Good references. Available July. C-5091.

ELECTRICAL ENGINEER, age 31, B. S. in E. E. Two years' electric car-shop experience; one year student engineer with power company; two years in engineering department of street railway company; one year electrical control of armament on aeroplanes; one year hydroelectric power studies. C-6077.

COMMUNICATION ENGINEER, 40, married, B. S., E. E. and E. E. degrees. Retired officer naval service. Twelve years' experience administration of communication organizations, development and operation radio-communication systems. Wide experience handling personnel. Three years director of radio, foreign government. Previous experience naval operator. Location, immaterial. Available July 1, 1931. C-9200.

ELECTRICAL ENGINEER, 34, married, graduated in Europe, with nine years' American experience covering drafting, testing, research, supervision of electrolysis work, operating and planning. Familiar with overhead and underground transmission and heavy electrical traction. Last two years as assistant electrical engineer with large hydro projects. Available on short notice. C-9170.

GRADUATE ELECTRICAL ENGINEER, desires substantial connection with public utility or industrial firm on power engineering as engineer or assistant to superintendent or engineer. Ten years' experience in power-plant test, operation, design, construction, and maintenance. Three years electrical engineer for industrial firm. Two years assistant to power engineer. B-8379.

ELECTRICAL ENGINEER, 35, married, B. S. in E. E., four years' experience in electrical design at steam and hydroelectric plants, switching stations, substations and transmission lines including field experience; two years design and construction of railway electrification. Also has had practical experience in industrial construction, factory and steel mill maintenance. References. C-9211.

SALES EXECUTIVE ENGINEER, electrical training and seven years' experience covering sales engineering, sales promotion, sales management. Has traveled extensively, acquainted with conditions in all sections of country. Well acquainted with New England. C-5431.

ELECTRICAL DESIGNER, age 36, married. Ten years' public utility experience in steam and hydroelectric plants, substations and industrial plants. Also served four years as fire insurance inspector. Graduate of technical school on electrical and mechanical subjects. C-7979.

ELECTRICAL ENGINEER, graduate, E. E. degree 1930, 25, American, single. Experience power-cable research and testing and allied work. Desires any kind of work in electrical engineering field. Best references. Available immediately. Any location considered. C-9188.

1930 GRADUATE OF E. E. under the cooperative plan at Georgia Tech. Worked alternate months with public utility company in Georgia in car-barn, gas, engineering, hydrogeneration and statistics departments. Since graduation has worked six months with transmission line construction crew. Any location. C-9210.

ELECTRICAL ENGINEER, 30, married, university graduate, two years' experience distribution engineering for large electrical manufacturer; six years' experience power-plant and substation maintenance, operation, design, and construction with large power company. Wants position with power company, engineering, or construction firm. Available upon short notice. Will go anywhere. C-9267.

RADIO ENGINEER, 33, broad training in research, development and production of radio receivers, accessories, and component parts; responsible charge of quality; commercial understanding of engineering relations to purchasing and manufacturing; advertising and sales experience; resourceful. Available to progressive organization in radio or allied fields. B-5752.

EXPERIENCED TRANSLATOR, ELECTRICAL ENGINEER by profession, French and German, would prefer to translate technical and scientific books. Best of references. B-7091.

GRADUATE ELECTRICAL ENGINEER, 1930, 24, single. Seven months' experience transmission-line construction. Excellent physical condition. Desires position with future. Location preferred, East. C-9238.

ELECTRICAL ENGINEER, college graduate, over 20 years' experience in high-voltage transmission line and power-station work, principally with Siemens Schuckert and Brown Boveri companies in Germany. Desires responsible position. C-9257.

ELECTRICAL ENGINEER, 31, single, graduate University of California (1927), varied experience, designing, developing, testing high-frequency measuring apparatus. Has had some work engineering department, electrical manufacturing and radio concern. Desires connection with public utility, industrial equipment company. Now employed on development high-frequency apparatus. Location preferred, New York City. C-6734.

ENGINEER, college graduate with B. S. in E. E., seeks connection as chief engineer or superintendent of industrial plant or office building. Fifteen years' broad experience in power installation, operation and maintenance of electrical, mechanical and steam equipment. Familiar with building operation and maintenance. References furnished with interview. C-9262.

SWITCHBOARD FOREMAN, ten years' experience with construction companies for public utilities, wiring, construction and installation of powerhouse switchboards and control apparatus. Shop experience, manufacturing switchboards. C-4831.

SENIOR STUDENT in electrical engineering, graduating in June from Colorado University, available July first. Desires position as a junior engineer, sales engineer or instructor in mathematics or electrical engineering subjects. Has had 18 months' practical work in electrical service and repair of power equipment prior to college. Location preferred, Southern or Western United States. C-9241.

ENGINEER, graduate Stevens, one and one-half years' G. E. Test, with broad knowledge of transmission operation gained during five years with public utility operating in the foreign field; seeks new connection either domestic or foreign. Would be valuable for staff of general superintendent; mechanical engineer with electrical experience. C-9177.

GRADUATE ELECTRICAL ENGINEER, 1929, age 24, single. Two years' experience in overhead distribution and transmission design, drafting, and estimating. Best of references. C-9256.

ELECTRICAL AND RADIO ENGINEER, 39, University graduate with B. S. in E. E. G. E. Test experience. Fifteen years in design, test and operation of radio and high-frequency circuits and apparatus. Married, two children. Location secondary importance, West preferred. Available immediately. C-9246-314-C-12-San Francisco.

GRADUATE ELECTRICAL ENGINEER, age 25. Two years' experience in power system operation, system planning and development; also experience in distribution and transmission engineering. Desires position in any location with public utility, or in any electrical line offering a future. Available upon short notice. References. C-9281.

RADIO ENGINEER, 35, married, A. B. in M. E., and Engineer in E. E. Fourteen years' experience, research, development, design, installation, and testing of radio transmitting equipment. Also experienced, patent investigations, office management, and purchasing of materials. Desires executive, research, or teaching position permitting advancement of art of radio communication. C-9251.

ELECTRICAL, MECHANICAL, CONSTRUCTION ENGINEER, 35, married. Experience in installation of automatic equipment in power stations, general construction about 11 years. Has five years air-corps service. Available upon notification. Location preferred, San Francisco, California. C-9247-314-C-15-San Francisco.

GRADUATE ELECTRICAL ENGINEER, 23, B. S., M. S. in E. E. Desires position, instructor in engineering department of college, university. Has fundamental, practical knowledge d-c., a-c. circuits and machines. Can teach engineering mathematics, physics. Has had some teaching experience; two years research work obtaining degrees. Available July 1st. Location, anywhere United States. C-9214.

GRADUATE ELECTRICAL ENGINEER, 29, one year Westinghouse Test course, six years engineering for large eastern utility. Familiar design, construction, and operation of distribution substations, customers' services, load dispatching and supervisory-control system. Desires responsible position with public utility, consulting engineers, or sales work with electrical manufacturer. C-8322.

RELAY ENGINEER, university graduate, ten years' practical experience, thoroughly familiar with all relay applications and testing, short-circuit studies, stability calculations, and all problems connected with system disturbances. Moderate salary. Available at once. C-9291.

ELECTRICAL ENGINEER, 25, married, desires engineering work. Has been on electrical seismograph for last two years. Work involved use of portable oscillograph and wireless telegraphy. Holds second-grade commercial operator's license. Has one year public utility experience and surveying experience. Personal interview desired. C-3035.

ELECTRICAL ENGINEER, 23, single, graduate Georgia School of Technology, B. S. degree in E. E. Cooperative plan 1930; five years' experience railroad shop all departments during cooperative course; one year experience with utility on manufacturing concern. Prefers Southeast. C-9292.

DISTRIBUTION ENGINEER, 29, single. Six years' experience on overhead distribution, estimating, design, construction and revamp in general office of large utility. Available immediately. Location preferred, West, but will consider others including foreign country. C-9307-314-C-13-San Francisco.

ENGINEERING SOCIETIES EMPLOYMENT SERVICE

57 Post St.
San Francisco
N. D. Cook, Manager

205 West Wacker Drive
Chicago
A. K. Krauser, Manager

31 West 39th St.
New York
W. V. Brown, Manager

MAINTAINED by the national societies of civil, mining, mechanical, and electrical engineers, in cooperation with the Western Society of Engineers, Chicago, and the Engineers' Club of San Francisco. An inquiry addressed to any of the three offices will bring full information concerning the services of this bureau.

Men Available.—Brief announcements will be published without charge; repeated only upon specific request and after one month's interval. Names and records remain on file for three months; renewable upon request. Send announcements direct to Employment Service, 31 West 39th Street, New York, N. Y., to arrive not later than the fifteenth of the month.

Opportunities.—A weekly bulletin of engineering positions open is available to members of the cooperating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

Voluntary Contributions.—Members benefiting through this service are invited to assist in its furtherance by personal contributions made within 30 days after placement on the basis of 1.5 per cent of the first year's salary.

Answers to Announcements.—Address the key number indicated in each case and mail to the New York office, with an extra two-cent stamp enclosed for forwarding.

JUNIOR ENGINEER, 1930, graduate, B. S. degree in E. E. Associate member of Sigma Xi. Eight months' practical experience in research, design, and testing with large radio concern. Desires position as engineering instructor or in any electrical line offering a future. Eastern location preferred. Salary secondary to opportunity. C-9300.

ELECTRICAL ENGINEER, age 28; single; considerable industrial experience; one year as graduate assistant; M. S., Iowa State College, 1930; B. S. Pennsylvania State College, 1925. Desires position as instructor with the prospect of a permanent teaching position. C-3202.

ELECTRICAL ENGINEER, 28, A. B., E. E. 1926. Two years as emergency man, one year as engineering assistant with a New York Power Company. Four years with a Telephone Company making studies of equipment and operating conditions and on service maintenance. Two years teaching mathematics in evening classes. References. C-9308.

HEATING ENGINEER, 12 years' experience, largely on industrial electric heating equipment, particularly heat treating and forging furnaces. University of Wisconsin graduate (1918). Some arc-welding and motor design experience. Familiar with research, design and sales practise. Locate anywhere. Prefer executive position. B-8838.

ELECTRICAL ENGINEER, B. S. degree in E. E. in 1925. Five years' experience in electrical equipment design, public utility operation, and field construction. Natural writing talent. Desire work in editorial or related fields. C-4875.

RADIO ENGINEERING GRADUATE, student in one of the greatest eastern universities, desires connections fitting his education. Has B. E. degree in E. E. and has been very active in radio engineering practise for seven years. Available at once, age 23 years. C-7315.

GRADUATE IN ELECTRICAL ENGINEERING, 1928, married; one year's experience on Westinghouse test floors assigned to traction apparatus. Has completed Westinghouse graduate student course. Has had approximately 18 months' experience as sales engineer. Especially interested in work within transportation industry, or as instructor in recognized engineering school. Excellent scholastic record and references. C-9309.

GRADUATE ELECTRICAL ENGINEER, 35, good technical school. Ten years' experience in electrical station construction and design drafting, including considerable mechanical experience. Latest position superintendent of design and construction of transformer substation. Preferring station design and construction with utility, would consider engineering industrial plant maintenance or operation. C-7043.

COLLEGE GRADUATE class of '29, B. S. degree in electrical engineering, 25, single, G. E. Test, general engineering and business courses. Interested in position in engineering department of manufacturing or utility company. Available at once. Location, Eastern United States. C-9003.

ELECTRICAL-MECHANICAL ENGINEER, 28 years old, experienced in power generation, distribution and application to industrial uses. Desires position as electrical-mechanical engineer in charge of operation, maintenance and repairs with manufacturing concern generating own power. C-9063.

GRADUATE ELECTRICAL ENGINEER with broad experience in development and design, executive and engineering on small electric motors, desires connections as engineer or chief draftsman. Available in from twenty to thirty days. Married. References. B-9395.

COLLEGE GRADUATE, 27, single, B. S. in E. E. Eighteen months General Electric Test, twenty-two months telephone equipment engineer. Desires position in manufacturing or utility company. Location preferred, Middle West, but, not essential. Available at once. C-9285.

ELECTRICAL ENGINEER, B. S. degree 1929, married, 33, American. Two years' experience as a draftsman-designer with large utility company. Experienced on outdoor and indoor high-voltage substations. Speaks Russian, (United States citizen). Well acquainted with Manchuria, China. Location, immaterial. C-6290.

ESTIMATING ENGINEER, B. S. degree in E. E., age 34, married. Ten years' experience with large company manufacturing electrical power equipment, including designing electrical and mechanical construction and calculating cost, weight and dimensions of this apparatus, in connection with customers' negotiations. Available at once. Location, immaterial. C-4633.

GRADUATE ELECTRICAL ENGINEER, single, age 25, eight months engineering assistant power department office of public utility, fourteen months equipment engineer handling installation and testing of toll line telephone equipment. Good general knowledge of building trades. Excellent references. Location, immaterial. C-8126.

ELECTRICAL ENGINEER, 24, single; B. S. in E. E., 1929; M. S. 1931. Westinghouse graduate student course. Some experience in acoustic and radio laboratories. Six months' experience with phototube and grid-glow tube applications. Natural writing ability. Available at once. Location, immaterial. C-9314.

GRADUATE ELECTRICAL ENGINEER, B. S. degree, age 24 and single. Experience in machine shop and steel construction work. Four years of practical and theoretical electricity in college. Willing to start at bottom and work up with a reliable company. Available any time. Location, anywhere in United States. C-9135.

ELECTRICAL ENGINEER, age 45, technical school graduate desires position with railway, consulting engineer, or industrial plant. Twenty-four years' experience with large street railway and electrical contractor on drafting, designing, estimating, construction and operation of power, distribution and miscellaneous electrical. Conversant with power reports, new projects, budgets and executive responsibility. C-7202.

ELECTRICAL ENGINEER, 1930 graduate, 22, single. One year on the Westinghouse student course. Desires position as instructor in electrical engineering. Available school year 1931-1932. References. Location, immaterial. C-9311.

ELECTRICAL ENGINEER, B. S. E. E., '29, M. S. E. E. '31, leading university, 18 months General Electric Test, 23, single. Desires to teach in technical university. Prefer Mid West. C-9320.

ELECTRICAL ENGINEER with Master's degree, industrial design and development of electrical-control equipment, authority on electrolytic condensers; married; will work anywhere except Russia. Available on six weeks' notice. Employed at present. Not interested in position without full responsibility. C-7288.

ELECTRICAL EXECUTIVE, 39, married. Thoroughly experienced in power plant and industrial construction, maintenance. Can handle men and improve service. Very well qualified to assume part of the responsibility of a busy executive. Replies confidential. C-2028.

ELECTRICAL ENGINEER for eight years in charge of design and construction of large switching stations up to 220,000 volts in the East, and with strong mechanical and structural antecedents seeks permanent connection. C-9332.

Membership

Recommended for Transfer

The Institute's board of examiners at its meeting of April 29, 1931, recommended the following members for transfer to the grade of membership indicated. Any objection to these transfers should be filed at once with the national secretary.

To Grade of Fellow

KELLY, MERVIN J., Vacuum Tube Development Engr., Bell Telephone Laboratories, Inc., New York.

KRAFT, CHRISTOPHER H., Supt. of Electrical Distribution, Union Electric Light and Power Co., St. Louis, Mo.

To Grade of Member

AJANI, FRANCESCO, vice-director, Societa Industrie Elettrotelefoniche, Turin, Italy.

ALLENDE, OCTAVIO E., asst. general mgr., Compania Electrica de Cartago, Costa Rica, C. A.

CARTER, E. L., consulting engr., 814 Continental Bank Bldg., Indianapolis, Ind.

COOPER ROBERT S., supervisor of communications, West Penn Power Co., Connellsville, Pa.

CORSON, LeROY, supervisor, N. Y. & Queens Elec. Lt. & Pr. Co., Flushing, N. Y.

FEDER, TOBIAS M., district sales mgr., Jeffery Dewitt Insulator Co., Chicago, Ill.

GOLDTHWAITE, GEORGE E., consulting engr., Hine, Goldthwaite & Mylott, New York.

MARQUIS, VERNON M., elec. engr., American Gas & Elec. Co., New York.

MARTIN, EDWIN R., motor engr., Delco Products Corp., Dayton, Ohio.

RALPH, ARTHUR J., technician, Yale University, New Haven, Conn.

ROTTY, OSCAR J., supt. of substations, Union Electric Lt. & Pr. Co., St. Louis, Mo.

SANO, SHIRO, president, Sano Electric Mfg. Co., Tokyo, Japan.

SCHULER, L. R., inspector, Public Service Co. of Northern Illinois, Chicago, Ill.

WRIGHT, SUMNER B., telephone engr., American Tel. & Tel. Co., New York.

Applications for Election

Applications have been received by the Secretary from the following candidates for election to membership in the Institute. Unless otherwise indicated, the applicant has applied for admission as an Associate. If the applicant has applied for direct admission to a grade higher than Associate, the grade follows immediately after the name. Any member objecting to the election of any of these candidates should so inform the Secretary before June 30, 1931.

Atkinson, C. R., General Electric Co., Fort Wayne, Ind.
Bailey, R. S., (Member), American Tel. & Tel. Co., New York, N. Y.
Balzer, E. W., Healds Engineering College, San Francisco, Calif.
Bangs, J. E., (Member), Suite 1122, Earle Bldg., Washington, D. C.
Bardwell, M. W., Syracuse Lighting Co., Inc., Syracuse, N. Y.
Barkson, J. A., American Tel. & Tel. Co., Cleveland, Ohio
Bonnett, A. A., Alaska Gold Mines Co., Thane, Alaska
Boulton, B. K., (Member), Beauharnois Construction, Beauharnois, Que., Can.
Buese, L. A., Los Angeles Gas & Electric Corp., Los Angeles, Calif.
Burleson, W. H., (Member), Ohio Brass Co., Mansfield, Ohio
Campbell, R. W., General Electric Co., New York, N. Y.
Clark, Maurice E., New England Tel. & Tel. Co., Boston, Mass.
Elliott, H. J., Atmospheric Nitrogen Co., Hopewell, Va.
Fouracre, V. W. M., M. Montgomery & Co., Ltd., Vancouver, B. C., Can.
Friedman, V. N., (Member), Jas. R. Kearney Corp., St. Louis, Mo.
Gills, E. T., Ohio Brass Co., Mansfield, Ohio
Gonzalez, J. J., Veracruz Electric Lt. Pr. & Traction Ltd., Veracruz, Mexico
Harris, C. E., Duke Power Co., Charlotte, No. Car.
Hatfield, B. F., Southern Bell Tel. & Tel. Co., Atlanta, Ga.
Herwegh, L. J., (Member), Atwater Kent Mfg. Co., Philadelphia, Pa.
Holmes, L. C., Rensselaer Polytechnic Institute, Troy, N. Y.
Hutson, R. V., Cincinnati & Suburban Bell Tel. Co., Cincinnati, Ohio
Ingles, J. A., Hydro-Electric Power Commission of Ontario, Toronto, Ont., Can.
Jack, F. M., New York Edison Co., New York, N. Y.
Kalen, E. T., N. W. Electric & Machine Co., Milwaukee, Wis.
Kanekeberg, A., Public Service Co. of Colo., Denver, Colo.
Kiltie, O., General Electric Co., Fort Wayne, Ind.
Kimbrell, M. R., (Member), Duke Power Co., Charlotte, No. Car.
Lyons, S. E., D. L. & W. Railroad Co., Hoboken, N. J.
May, D. M., Collins Flashlight Corp., New York, N. Y.
McGuire, F. J., Otis Elevator Co., Yonkers, N. Y.
Morgan, F. D., Allied Engineers, Inc., Jackson, Mich.
Morris, F., Saskatchewan Power Commission, Moose Jaw, Sask., Can.
Muller, H. S., New Jersey Bell Tel. Co., Newark, N. J.
Myers, C. F., Puget Sound Power & Light Co., Wenatchee, Wash.
Needham, G. H., New Jersey Bell Tel. Co., Newark, N. J.
Organ, J. W., Union Electric Light & Power Co., St. Louis, Mo.
Peterson, A. W., Continental Electric Co., Inc., Newark, N. J.
Peterson, N. T., MacMillen Elec. & Mfg. Co., Los Angeles, Calif.
Powell, J. A., (Member), W. S. Barstow & Co., Inc., Reading, Pa.
Rogers, T. A., University of California, Berkeley, Calif.
Russell, H. G., 37 Harvard St., Worcester, Mass.
Slezak, S. T., New York Telephone Co., New York, N. Y.
Warrington, A. R., General Electric Co., Philadelphia, Pa.
44 Domestic

Foreign

Gara, E., Chile Exploration Co., Chuquicamata, Chile, So. America
Hofman, S. P., The General Electric Co., Ltd., Witton, Birmingham, Eng.
Kempe, R., Asea, Ludvika, Sweden
Robinson, C. S., Cia. Chilena de Electricidad Ltd., Santiago, Chile, So. America
Singh, G., Mussoorie Hydro-Electric Scheme, Dehradun, U. P., India
Stock, J. M., Cia. Interprovincial de Servicios Publicos S. A., Buenos Aires, Argentina, So. America
Texier, J., M. M. Schneider & Cie, Paris, France
van Dyk, J., Philips Lamps (A'sia) Ltd., Sydney, N. S. W., Australia
8 Foreign

Engineering Literature

New Books

In the Societies Library

AMONG the new books received at the Engineering Societies Library, New York, during April are the following which have been selected because of their possible interest to the electrical engineer. Unless otherwise specified, books listed have been presented gratis by the publishers. The Institute assumes no responsibility for statements made in the following outlines, information for which is taken from the preface or text of the book in question.

Electrical Drafting and Design. 2nd edit. By C. C. Bishop. N. Y., McGraw-Hill Book Co., 1931. 190 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth, $2.00.——Covers the ordinary work done in the office of an engineer, contractor or power company, in drafting and designing layouts, switchboards, residence and power wiring, etc. A collection of tables is included. The book bridges the gap between the usual course in mechanical drawing and the practical methods of the industry. The new edition has been revised to meet changes in underwriters' rules and in apparatus.

Grundwasser-Abdichtung. 3. Auflage. By J. Schultze and W. Sichardt. Berlin, W. Ernst u. Sohn, 1931. 69 pp., illus., diagrs., tables, 10 x 7 in., paper. 5-r. m.——A concise review of practical methods for waterproofing mortar and concrete in underground structures. The advantages and disadvantages of different methods are described and directions given for their use.

Grundzüge der Technische Schwingungslehre. By O. Föppl. Berlin, J. Springer, 1931. 212 pp., illus., diagrs., tables, 8 x 5 in., cloth. 9.50-r. m.——2nd edit. A concise treatise on the theory of vibration and its applications in engineering. The effects of vibration upon structural materials, methods of calculating frequencies, damping devices, the prevention of vibration in reciprocating machines, and similar topics are discussed.

High Frequency Alternating Currents. By K. McIlwain and J. G. Brainerd. N. Y., John Wiley & Sons, 1931. 510 pp., illus., diagrs., charts, tables, 9 x 6 in., cloth. $6.00.——A course for senior students, as given at the University of Pennsylvania. The theory of these currents is presented and their use in telephony, radio communication, remote control, and other purposes are discussed.

High-Speed Diesel Engines. By A. H. Goldingham. Lond., E. & F. N. Spon, Ltd., 1931. 148 pp., illus., diagrs., charts, tables, 9 x 6 in., 10s. 6d.——After an introductory chapter upon the theory and advantages of this engine, the various systems of fuel injection are described in detail. The remaining two-thirds of the book describes various types of high-speed Diesel engines. The book summarizes the present position of this engine in convenient form.

"Hütte" des Ingenieurs Taschenbuch. 26 Auflage, 1 Band, 1931. By Akademische Verein Hütte. Berlin, W. Ernst u. Sohn, 1931. 1199 pp., diagrs., charts, tables, 8 x 5 in., cloth, 17,50 r. m.; leather, 20,50 r. m.——The first volume of the new edition covers such fundamental matters as mathematics, mechanics, technical physics, heat, strength of materials, materials, measurements and surveying. Compared with the previous edition, this is ten per cent larger and has been thoroughly revised throughout. Hütte still remains the most comprehensive collection of engineering tables, formulas and general information in print.

Mathematical Tables and Formulas. By R. D. Carmichael and E. R. Smith. Bost. & N. Y., Ginn & Co., 1931. 269 pp., diagrs., tables, 9 x 6 in., cloth. $2.00.——This compilation aims to meet the needs of students in mathematics courses and other courses that require mathematical computations or involve mathematical processes. It contains the usual logarithmic and trigonometric tables, up to five places, needed in the study of college algebra and trigonometry; other numerical tables frequently used in computation; and a collection of mathematical formulas, integrals and series.

Modern Diesel Engine Practice. By O. Adams. N. Y., Norman W. Henley Publ. Co., 1931. 656 pp., illus., diagrs., tables, 10 x 6 in., cloth. $6.00.——A descriptive work, intended primarily for the operating engineer and the owner. Special attention is given to applications of Diesel engines, and to operating and maintenance practise. Aircraft engines and locomotives are included.

Non-Interpolating Logarithms, Cologarithms and Antilogarithms. By Frederick W. Johnson. San Francisco, Simplified Series Publ. Co., 1930. 23 pp., tables, 9 x 6 in., limp cloth, note-book edit. $1.60; fabrikoid, $2.25; full leather, $4.00——Four-place and five-place logarithms and antilogarithms, and four-place cologarithms can be obtained from these tables by inspection, without any calculation. The tables are very compactly printed, in clear type, on substantial paper, and are thumb indexed. Additional tables of constants, metric conversion factors and other frequently used data are included.

Pocket-Book of Electrical Rules and Tables. By W. R. Cooper and R. Appleyard. Phila., J. B. Lippincott, 1931. 765 pp., illus., diagrs., tables, 7 x 4 in., cloth. $4.00.——A reference book giving special attention to electrical instruments and measurements, conductors, submarine cables, telephony and radio, but also treating more briefly of electrometallurgy, dynamos, balancers, transformers, power-factor improvement and illumination. The book has long been valued by cable and telegraph engineers as a practical pocketbook. Various specialists have contributed to the revised edition.

Radio Handbook, including Television and Sound Motion Pictures. By J. A. Moyer and J. F. Wostrel. N. Y., McGraw-Hill Book Co., 1931. 886 pp., illus., diagrs., charts, tables, 8 x 5 in., cloth. $5.00.——A concise but comprehensive reference book for the radio engineer. The authors have summarized the existing data upon radio apparatus, not only for telephony and telegraphy, but also for industrial power control and similar purposes.

Radioelements and Isotopes: Chemical Forces and Optical Properties of Substances. By K. Fajans. N. Y., McGraw-Hill Book Co., 1931. 125 pp., diagrs., charts, tables, 9 x 6 in., cloth. $2.50.——A review of the researches of the author and others upon the nature of chemical forces and the relation of these forces to the optical properties of atomic and crystal structures. The book is based upon the author's lectures at Cornell University during 1930.

S. A. E. Handbook. 1931 edit. Society of Automotive Engineers, N. Y. 752 pp., diagrs., charts, tables, 8 x 4 in., cloth. $5.00 to non-members.——Contains the standards and recommended practises of the Society, revised to March, 1931.

Standard Wiring for Electric Light and Power, 1931. By H. C. Cushing, Jr. Publ. by H. C. Cushing, Jr., N. Y., 1931. 503 pp., illus., diagrs., tables, 7 x 4 in., leather, $3.00.——The new edition of this well-known handbook has been thoroughly revised to represent the latest approved practise. Specific directions are given for wiring for all ordinary purposes, for installing motors, generators and storage batteries, and for lighting.

Vergrösserung der Effektiven Höhe von Flugzeugschleppantennen. (Luftfahrtforschung Bd. 8, s. 141-154, Heft 6, 3 März 1931.) By F. Eisner, G. Sudeck, R. Schröer and O. Zinke. München, R. Oldenbourg, 1931. Illus., diagrs., tables, 12 x 8 in., paper, 2,80 r. m. ——Reports the results of an investigation of the efficiency of trailing antennas for aircraft radio stations and describes an improved L-shaped antenna.

List of Alloys with Physical Properties of Typical Alloys. By W. Campbell. Phila., American Society for Testing Materials, 1930. 65 pp., 9 x 6 in., paper, $1.50; cloth, $2.00. Over 2,500 alloys are represented. These are mostly non-ferrous alloys, but certain non-corrosive and heat-resistant iron alloys are included. The composition of each alloy is given and, in some cases, the physical properties.

Personnel Problems. Methods of Analysis and Control. By F. E. Baridon and E. H. Loomis. N. Y., McGraw-Hill Book Co., 1931. 452 pp., diagrs., charts, tables, 9 x 6 in., cloth. $5.00.——Intended as guide in the study and solution of these problems. The questions that constantly arise under modern industrial conditions are outlined specifically, and methods for their analysis and control are suggested.

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☐ **31-61**	W. A. Lewis and L. S. Tippet	Fundamental Basis for Distance Relaying on Three-Phase Systems
☐ **31-65**	R. L. Young and R. L. Lunsford	Automatic Power Plants for Telephone Offices

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Selected Items From Engineering Index Service

SELECTED references to current electrical engineering articles from Engineering Index Service's review of some 1,800 technical periodicals are given in the following columns.

All articles indexed are on file in the Engineering Societies Library, New York, which will furnish photoprints of any article at a cost of 25 cents per page or make translation of foreign articles at cost.

Boilers

ELECTRIC. Packed Heat from a New Type of Electric Steam Generator, H. Bidwell and L. H. Jones. *Indus. and Eng. Chem.*, vol. 23, no. 3, Mar. 1931, pp. 298-300, 2 figs. Description of generator suitable for hospital sterilizers, pressure cooking retorts or industrial processes where large amount of steam is required for short time which has reservoir properly located between high- and low-water levels which serves as source of energy, so that pressure from boiler is immediately available when required.

Cables

FAULT LOCATION. Service d'études et de recherches techniques (Study of Underground Conductors and their Failures). *Annales des Postes Télegraphes et Téléphones*, vol. 20, no. 2, Feb. 1931, pp. 153-160, 8 figs. By running telephone frequencies through cable and by using loop operated amplifier, course of cable or of single conductor in group of conductors and various types of faults and insulation troubles can be detected.

HIGH TENSION. Elektrische Arbeitsuebertragung durch Hochspannungskabel (Electric Power Transmission Through High-Voltage Cables), J. Kuehle. *Elektrotechnische Zeit.*, vol. 52, no. 12, Mar. 19, 1931, pp. 373-377, 15 figs. Comparison between operating characteristics of cable and overhead lines; advantages and disadvantages of both systems shown by numerical comparison; three-conductor and single-conductor cables in three-phase system; lead sheath losses and process in dielectrics.

LEAD SHEATHING. Kristallgefuege und Disglomeration des Bleies (Crystaline Structure and Disglomeration of Lead), O. Haehnel. *Elektrische Nachrichten Technik*, vol. 8, no. 2, Feb. 1931, pp. 77-88, 16 figs. Metallographic measurement of crystallite grain of pure lead yield mean diameter of 8 mm. being largest crystallites which ever have been observed in cast lead cooled in manner as described; all lead drawn from cable lead presses has much smaller crystallites; grain in cable press is determined by operating temperature and working pressure.

METAL SHEATHED. De la préférence à donner aux alliages plomb-antimoine, plomb-antimoine cadmium sur le plomb pur dans la fabrication des gaines de cables électriques et téléphoniques (Superiority of Lead-Antimony, Lead-Antimony-Cadmium over Pure Lead in Manufacture of Sheathing for Electric and Telephone Cables), H. Godin. *Revue Universelle des Mines*, vol. 5, no. 4, Feb. 15, 1931, pp. 106-109, 1 fig. Failure of cable sheaths without apparent cause; results of analyses of failure by Archbutt and Radwdon; means of avoiding intercrystalline failures of cable sheaths.

POTHEADS. Die bisherige Entwicklung der Kabelendverschluesse ohne Vergussmasse (Present Development of Cable Potheads Without Dilling Compound), E. Eule. *Siemens Zeit.*, vol. 11, no. 2, Feb. 1931, pp. 95-102, 20 figs. Equipment of Siemens and Schuckert, its features, application and installation are described.

STANDARDS. Standard Color Code for Control Cable, G. Sutherland. *Power Plant Eng.*, vol. 35, no. 7, Apr. 1, 1931, pp. 413-414. Color scheme prepared by joint committee of N.E.L.A. and N.E.M.A. following extensive review of questionnaires sent to 26 leading American utility companies and survey of field tests conducted by joint committee; standard color scheme table for control cable.

TELEPHONE—LIGHTNING. Blitzschlaege in Fernkabelanlagen (Lightning Strokes in Long Distance Telephone Cables), P. Kleinsteuber. *Telegraphen und Fernsprech Technik*, vol. 20, no. 2, Feb. 1931, pp. 48-50, 5 figs. Various typical cases and their analysis.

Circuit Breakers

OIL. New Ironclad Switchgear. *Engineer*, vol. 151, no. 3925, Apr. 3, 1931, p. 386, 2 figs. Following success of "T A P" circuit breaker by Crompton-Parkinson, Ltd., of Chelmsford, firm has designed metal-clad oil circuit breaker on somewhat similar lines; unit is made for currents up to 300 amperes at 3,300 volts, or 600 amperes at 650 volts for three- or four-wire circuits, and can be used singly or number of units can be made to form switchboard.

Circuits

VECTOR ANALYSIS. Mechanical Aids in the Construction of Vector Diagrams, B. S. Willis. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 224-227, 6 figs. Numerical solutions combined with graphical representations; various examples from electric circuit practise are given.

Compensators

Détermination d'un groupe formé par un transformateur à trois enroulements et un compensateur synchrone (Determination of System Formed by Three Winding Transformer and Synchronous Compensator), F. Hallopeau. *Revue Générale de l'Electricité*, vol. 29, no. 9, Feb. 28, 1931, pp. 338-343, 9 figs. Power calculation of compensator connected to network by means of transformer as outlined; mathematical and graphical solution; vector diagrams of transformer.

Condensers

STATIC. Les condensateurs statiques et l'amélioration du facteur de puissance (Static Condensers and Improvements of Power Factor), *Science et Industrie*, vol. 15, no. 205, Feb. 1931, pp. 88-92, 11 figs. Problem; electric rates; determination of corrective capacity in kva. for given installation; various solutions; comparison between condensers and synchronous motors; electric condenser as accepted electric equipment.

TESTING. Bemerkungen zur Pruefung von Kondensator-Durchfuehrungen (Remarks on Testing of Condenser Bushings), L. Kumlik. *Elektrizitaetswirtschaft*, vol. 30, no. 6, Mar. 1931, pp. 171-172. Manufacture is started by other hard paper plants since exhaustion of Nagel patents; as these have no previous experience critical analysis is given of usual testing method from which conclusions may be drawn as to quality of product.

Conduits

UNDERGROUND. Expérience d'un nouveau procédé de construction des conduites multitubularies sans joint (Test of New Process of Construction of Multi-Duct Jointless Conduits), M. Moine and L. Daumard. *Annales des Postes Télégraphes et Téléphones*, vol. 20, no. 3, Mar. 1931, pp. 173-192, 12 figs. Description of Cravetto design, tested in Nice, France; design calls for reinforced-concrete monolith blocks containing as many as 12 parallel circular ducts 10 cm. in diameter.

Contactors

A Periodic Contactor Operated by a Neon-Tube Oscillator, H. J. Reich. *Rev. Sci. Instruments*, vol. 2, no. 3, Mar. 1931, pp. 164-170, 5 figs. Simple device, capable of closing circuit periodically at any desired frequency and holding it close for any desired fraction of cycle, finds frequent use as laboratory or lecture demonstration apparatus; writer had occasion to design such instrument, in which timing device was neon-tube oscillator; reliability and general usefulness of this device during almost year; design and constructional details.

Discharge

ELECTRODELESS. Sur un nouvel aspect de la décharge en haute fréquence (New Phenomenon in Electrodeless Discharge), M. Chenot. *Académie des Sciences—Comptes Rendus*, vol. 192, no. 1, Jan. 5, 1931, pp. 38-40; see also brief translated abstract in *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, p. 166. Experiments on electrodeless discharge obtained with 3.4-m. waves led to appearance of series of stationary waves which indicate wave propagation along tube at velocity between 3 and 5 per cent of velocity of light; author had previously suggested that long-delay radio echoes may be due to such propagation at greatly reduced velocities.

Education

ENGINEERING. Report of 1930 Survey of Engineering Education, F. L. Bishop. *Jl. Eng. Education*, vol. 21, no. 7, Mar. 1931, pp. 1-77. Survey to secure measure of progress which had been made in engineering education in each institution.

Electric Drive

ROLLING MILLS. Large Rolling Mill Motor. *Elec. Times*, vol. 79, no. 2056, Mar. 19, 1931, p. 527, 2 figs. At present time there is large rolling mill motor on test bed at Stafford works of English Electric Co., for replacing existing steam engine driving 27-in. three-stand reversing mill at Brown Bayley's Sheffield works; it operates on form of Ward-Leonard Ilgner system and comprises main driving motor, flywheel motor generator set, three exciters, slip regulator and necessary control; continuous r. m. s. capacity b.hp. at 30 r. p. m. is 1980; speed range at constant torque, r. p. m. is plus minus 0/30; speed range at reduced torque, r. p. m. is plus 30/70; armature, volts is 536.

PAPER AND PULP MILLS. Synchronous Motors in the Paper Industry, D. R. Shoults. *Paper Trade Jl.*, vol. 92, no. 13, Mar. 26, 1931, pp. 47-50, 3 figs. Advantageous features of synchronous motor drive in paper industry; Korndorffer method; automatic control; pulp grinder drives; Jordon and beater drives; pumps, air compressors and screens; chipper drive. Before Tech. Assn. of Pulp and Paper Industry. See similar article by author, "Electrical Developments," previously indexed from Paper Mill, Jan. 3, 1931, under heading, Paper and Pulp Mills—Electric Equipment.

Electric Lines

HIGH TENSION GROUNDING. Umfassende Erdungsanlage in eimen 380/220 V Verteilnetz (Extensive Grounding Installation in 380/220 Volt Distribution Network), C. Richard. *Assn. Suisse des Electriciens—Bul.* vol. 22, no. 7, Apr. 3, 1931, pp. 166-170, 10 figs. Possibilities available for decrease of ground voltage in case of disturbance; method applied to this purpose in Bassecourt, control test by which it was shown that for all cases of grounding no ground voltages over 50 kv. occurred.

RELAYS. Theory and Application of Relay Systems Low Voltage Transmission Lines—I, P. H. Robinson and I. T. Monseth. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, pp. 231-237, 17 figs. Three principal types of low-voltage circuits, namely, radial, parallel feeder, and loop systems each require different scheme of relay protection; no detailed study of short-circuit values is ordinarily required for simple radial system, and ordinary over-current relays may be used; with parallel feeders, selective-differential current relays can be applied at generating station end of line, and at substation end, directional over-current relays may be applied; application of relays to loop systems; selective timing of relays.

RURAL — LIGHTNING. La protection contre la foudre des réseaux de distribution d'énergie électrique à basse tension (Protection Against Lightning of Low Voltage Electric Power Distribution Networks), C. Ledoux. *Revue Générale de l'Electricité*, vol. 29, no. 12, Mar. 21, 1931, pp. 467-476, 10 figs. Results of recent investigation have shown that with increasing rural electrification, number of cases of lightning stroke have actually increased; Dauzére together with author have traced relation between geological nature of soil and frequency with which strokes occur; solutions proposed by P. Juppont and C. Dauzére are examined.

Electrolytes

Les Electrolytes Forts (Strong Electrolytes), R. Dufour. *Societe Francaise des Electriciens—Bul.*, vol. 1, no. 2, Feb. 1931, pp. 128-139, 1 fig. Consequences of theory of Debye with regard to conductibility are set forth.

Elevators

ELECTRIC. Elevator Installation and the General Building Contractor. *Gen. Bldg. Contractor*, vol. 2, no. 3, Mar. 1931, pp. 61-68, 6 figs. Method for computing elevator requirements;

typical elevator layout with overhead machinery; power panel and sizes of conduits; parts and devices that may have to be installed on modern high-speed elevator; tabulation of items.

DESIGN. Tells of Elevator Engineering Progress, J. Sozansky. *Power House*, vol. 25, no. 3, Mar. 1931, p. 52. Historical review of electric elevator developments; self-leveling type; operatorless cars; wasted rentable space. Before Montreal District Engins.' Assn.

Frequency

MEASUREMENTS. Ueber die Messung sehr kleiner Frequenzen und ihre Anwendung fuer Fernmessungen (Measurements of Very Low Frequencies and Their Application for Remote Measurement), E. Hudec. *Elektrotechnische Zeit.*, vol. 52, no. 12, Mar. 19, 1931, pp. 380-385, 10 figs. Impulse frequency method; use of ballistic instruments; generation of nearly constant current by means of condenser choke arrangement; decreasing crest intervals through repeated smoothening; repeated switching of short-circuited cable, use of filters, etc.

Furnaces

ANNEALING. Electrically Heated Annealing Furnaces, J. C. Woodson. *Heat Treating and Forging*, vol. 17, no. 3, Mar. 1931, pp. 285-288 and 291, 7 figs. Progress in design and application of annealing furnaces for ferrous and non-ferrous metals; economies for casting annealing runs from 8 to 15 lb. per kw-hr.; temperatures range from 950 to 1,650 deg. fahr., for carbon steel and to 1,950 deg. fahr. for manganese steel.

CALCIUM CARBIDE. La nouvelle usine à carbure et cyanamide de wingles (New Carbide and Cyanamide Plant of Wingles), R. Sevin. *Jl. du Four Electriques*, vol. 40, no. 2, Feb. 1931, pp. 51-58, 10 figs. List of plants in Europe and United States giving types and capacity of electric furnaces; detailed description of plant of Société des Mines de Lens, containing 2 lime kilns of 60 tons; carbide plant and 2 Miquet electric furnaces of 6,000 kw.; and their control.

INDUCTION. Tonnage Melting by Coreless Induction, E. F. Northrup. *Fuels and Furnaces*, vol. 9, no. 4, Apr. 1931, pp. 473-478, 7 figs. First of series covering fundamental principles of operation and construction of coreless induction furnace as applied to tonnage melting; development of high-frequency coreless-induction furnace; power requirements and sizes of furnaces and features of construction. (To be continued.)

MELTING. The Russ Induction Furnace. *Engineering*, vol. 131, no. 3404, Apr. 10, 1931, p. 497, 3 figs. Furnace manufactured by Industrie Elektro-Ofen G. m. b. H., Cologne, has normal capacity of 600 kg. and is capable of dealing with all types of non-ferrous metals; important feature is that furnace can be supplied from ordinary mains through Scott-connected transformer.

REFRACTORY MATERIALS. Refractory Materials for Electric Furnaces—I, A. B. Searle. *Metal Industry (Lond.)*, vol. 38, no. 13, Mar. 27, 1931, pp. 333-335. Copper and its alloys, including bronze, gun metal, brass, copper-nickel, and phosphor-bronze; refining furnaces; lining; use of magnesia; bricks for lining; crucibles; roof; annealing furnaces.

Fuses

HIGH TENSION. Die neue Hockspannungs-Hochleistungsicherung (H-H-Sicherung) der SSW (New High Tension High Capacity Fuse of Siemens Shuckert Company-(H. H. Type Fuse), H. Laepple. *Siemens Zeit.*, vol. 11, no. 2, Feb. 1931, pp. 65-70, 9 figs. New design of which fusing capacity is so high that they may be applied directly for short circuit protection of transformers and line taps, without use of reactors or resistances.

Generators

AUTOMOBILES. Electric Lighting Equipment, H. Cousins. *Automobile Engr.*, vol. 21, no. 278, Mar. 1931, pp. 100-106, 26 figs. Design and operation of various types of dynamos; functioning of regulators with particular regard to consideration of service requirements and reliability; diagrams illustrate C.A.V., Scintilla, and Bosch compensated voltage control system.

COILS. The Importance of Accurately Wound Field Coils, J. C. de la Rosa. *Elec. News*, vol. 40, no. 6, Mar. 15, 1931, pp. 57-58, 1 fig. By rewinding each of 12 field coils of rotary to standard equivalent resistance sparking was completely eliminated.

Heating

Industrial Applications of Electric Heat, L. M. Jenks. *Elec. Specifications*, vol. 3, no. 4, Apr. 1931, pp. 12-13, and 45, 4 figs. Last 10 years have brought development and perfection of so many new and unusual electric heating devices that it seems nothing is impossible; primarily, it may be said that electricity makes better product at lower cost; labor item should receive special consideration where product is to be machined or polished after heating process.

BUILDINGS. The Electric Heating of Buildings. *Engineering*, vol. 131, no. 3402, Mar. 27, 1931, p. 415. Review of two papers read before Institution of Civil Engineers and Institution of Electrical Engineers, respectively; first, by S. M. Saunders and W. L. Swale, describes results obtained from electric thermal storage as applied to building heating; includes list of 22 such installations in Great Britain; second paper, by T. J. Illingworth, deals with economic application of electricity to space heating by all principal systems, and examines several sources of loss of which account must be taken in making comparison between different systems.

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INDIVIDUAL comments and suggestions are invited; they should be made promptly and addressed directly to the A. I. E. E. Editorial Department, 33 West 39th Street, New York, N. Y.

The Electrical Heating of Buildings, R. Grierson. *Instn. Elec. Engrs.—Advance Paper*, Mar. 2, 1931, 48 pp., 21 figs. Types of electric warming equipment; general details and considerations; ascertained monthly cost of continuous electric warming of individual rooms in Central London; graph showing estimated and actual weekly consumption for 20-kw. low-temperature ceiling-panel installation; graph connecting mean temperature-rise and weekly consumption for 20-kw. low-temperature ceiling-panel installation; data relating to thermal-storage installations; data relating to direct electric heating installations, etc.

Hoists

MOTORS. Application of Two-Speed Induction Motors to Monorail Electric Hoists, C. E. Schirmer. *Am. Soc. Mech. Engrs.—Advance Paper*, for mtg. Apr. 13-18, 1931, 2 pp. Use of two-speed squirrel cage induction motors upon monorail hoists has been neglected until recently, and since use of such motors bestows worth while operating characteristics to such hoists at low cost, their more frequent use for such service is assured; chart showing actual speeds for various loads S-1 1-ton 2-speed Robbins & Myers electric hoist.

Hydroelectric

AUTOMATIC POWER PLANTS. Fully Automatic Hydro Power Plant, P. J. Croft, J. R. Desloover and D. Hutchison. *Can. Engr.*, vol. 60, no. 10, Mar. 10, 1931, pp. 11-14, 6 figs. Operation of electrical equipment at Upper Notch Plant of Northern Ontario Power Co.; equipment consists of two 48-ft. head, 6,500-hp., 125-r. p. m. hydraulic turbines direct connected to two 6,500-kva., 11,000-volt, 25-cycle generators; fully automatic control and switching equipment designed for possible remote control from distant supervisory plant; metal-clad switchgear; four 4,500-kva., 11,000/110,000-volt, 25-cycle transformers.

13,000-hp. Fully Automatic Hydroelectric Plant, P. J. Croft, D. H. Hutchison and J. R. Desloover. *Elec. News*, vol. 40, no. 6, Mar. 15, 1931, pp. 39-42 and 48, 7 figs. Upper Notch plant of Northern Ontario Power Co., situated on Montreal River 12 mi. south of Cobalt in heart of Canada's largest mining district, is one of Canada's largest fully automatic hydroelectric generating stations and represents latest practise in this type of control; it contains two 6,500-kva. 11,000-volt, 25-cycle generators, two 48-ft. head, 6,500-hp. 125-r. p. m. turbines, with fully automatic control.

POWER PLANT EFFICIENCY. Automatic Hydro Plant Economy Proved by Experience, J. M. Gaylord. *Elec. World*, vol. 97, no. 12, Mar. 21, 1931, pp. 532-535, 4 figs. Program of rehabilitation of smaller hydroelectric plants, which has resulted in 17 of these plants being made automatic or semi-automatic by Southern California Edison Co., Ltd., since 1919; 11 years' experience in operation of semi-automatic plants on system has demonstrated very definite savings in operating labor; under manual operation 17 plants required 77 operators while with automatic operation 33 operators are employed; reduced labor cost and housing expense amount to 57 per cent and turnover to 66 per cent; plants pay for themselves in 5½ years.

Hysteresis

Recherches sur la thermodynamique de l'Hystérésis (Studies on the Thermodynamics of Hysteresis), A. Guilbert. *Societé Francaise des Electriciens—Bul.*, vol. 1, no. 2, Feb. 1931, pp. 175-202, 11 figs. Experimental verification of theory expounded in Revue Générale d'Electricité of Jan. 5, 1929, indexed in Engineering Index 1929, p. 970.

Industrial Plants

PURCHASED VS. GENERATED POWER. Was darf die Kilowattstunde kosten? (Permissible Cost of Kilowatt Hour; Diesel Engine vs. Electric Motor), K. Dolzmann. *Elektrizitaetswirtschaft*, vol. 30, no. 6, Mar. 1931, pp. 149-157, 13 figs. General viewpoints for decision in problems of purchase of electric power or generation in own plant are discussed for small and average plants; factors and possibilities to be considered in valuation of Diesel engine and electric motors for this type of plant are analyzed; all necessary data for both types are given.

Insulating Oil

CARBON BLACK EFFECT. Effect of Carbon Black on Insulating Oils, W. B. Wiegand, C. R. Boggs and D. W. Kitchin. *Indus. and Eng. Chem.*, vol. 23, no. 3, Mar. 1931, pp. 273-276, 6 figs. Series of experiments designed to illustrate mechanism of action of carbon black is described; results indicate that action is one of removing moisture and/or electrolytes; brief summary of other methods for treating new and used insulating oils and of more important literature.

DIELECTRIC LOSSES. Dielektrische Verluste in Oelen (Dielectric Losses in Oils), A. Gemant. *Zeit. fuer. Technische Physik*, vol. 11, no. 12, Dec. 1930, pp. 544-545. Proof that losses in oil at low frequencies are due to different process (Wagner effect) from that causing them at high frequencies (Debye effect).

Lamps

Urges Large Lamps in Modern Illumination, M. M. Samuels. *Elec. World*, vol. 97, no. 13, Mar. 28, 1931, pp. 595-597, 1 fig. One peculiar feature has established itself in whole development of modern lighting equipment; it is so persistent and so objectionable that it seems necessary to discuss it in detail; getting away from candles and round bulbs, modern units appear principally in form of flat glass over very shallow fixtures or long glass panels or metal panels likewise on very shallow fixtures, all requiring long tubular lamps. Before Illum. Eng. Soc.

GLOW. Neue Gasentladungslichtquellen (Novel Gas Discharge Sources of Illumination), M. Pirani. *Lichttechnik (Supp. to Elektrotechnik u. Maschinenbau)*, vol. 8, no. 1, Mar. 15, 1931, pp. 1-3, 2 figs. New types in which many of disadvantages of previous types have been overcome; they are manufactured in two types, one with excitation in negative glow light used for television and similar purposes and high-capacity tubes with excitation in positive column; efficiency is 15 to 20 per cent.

Light and Lighting

Moderne Beleuchtungsarten und Leuchten, ihre Anwendung, Anlage und Wirtschaftlichkeit (Modern Methods of Lighting and Equipment, Their Application, Installation and Economy), G. Herkt. *Deutsche Bauzeitung*, vol. 65, no. 11-12, Feb. 4, 1931, pp. 29-36, 48 figs. Object and light intensity; room lighting and color; table showing light intensities for various rooms and locations; outside lighting; various samples of modern interior and exterior lighting; show window, indoor lighting, etc.

Foot-Candle Effectiveness a Measure for Illumination, M. Luckiesh. *Elec. World*, vol. 97, no. 12, Mar. 21, 1931, pp. 553-554. Reasonableness of demand for 10-ft. candles for visual work of this type may be tested; visibility of letters in telephone directory with letters of same size printed on fine book-paper with deep black ink are compared in table.

FILTERS. Filters for the Reproduction of Sunlight and Daylight and the Determination of Color Temperature, R. Davis and K. S. Gibson. *U. S. Bur. Standards—Miscellaneous Pub.*, no. 114, Jan. 21, 1931, 165 pp., 71 figs. Spectral energy distributions; component materials of filters; methods of computation; use of filters; spectrophotometric data; examination and trial of completed filters; preparation of Davis-Gibson filters. Bibliography.

VISUAL EFFICIENCY. Visual Performance Under Daylight, Incandescent, Mercury Vapor, and their Mixtures, K. Y. Tang. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 3, Mar. 1931, pp. 258-274, 6 figs. partly on supp. plates. Rapidity with which detail of test object could be perceived, using, at same levels, usual light sources, alone and in combination; illumination levels studied were 5- 10- and 20-ft. candles in test object; each kind of light was used separately at all three intensities, and combinations of two and three kinds in equal amounts were also used at all three levels.

Lightning

CONDUCTORS. Lynafledere (Lighting Erector), L. Ernst. *Elektroteknikeren*, vol. 27, no. 4, Feb. 22, 1931, pp. 67-79, 12 figs. Study of proper layout and wiring of conductors for all types of buildings; importance of factor controlling action of lightning conductor such as dimensions of building and materials, geological factors, etc.

Materials Handling

MANUFACTURING PLANTS. Material Handling in Mass Production at the General Electric Plant, H. C. Rundle. *Am. Soc. Mech. Engrs.—Advance Paper*, for mtg. Apr. 13-17, 1931, 5 pp. Conveyor system used throughout various buildings where refrigerators are made at General Electric Co., has eliminated congestion, retracing of material routes, delays in schedule, spoilage of materials, and maintenance and replacement of industrial trucks; conveyor serves as traveling stockroom, thus releasing floor space for use in manufacturing operations.

Measurements

ALTERNATING-CURRENT. A New Series of Alternating Current Instruments. *World Power*, vol. 15, no. 87, Mar. 1931, pp. 199-201, 4 figs. Alternating current measurements have long been at disadvantage as compared with direct-current measurement; perfection, during last few years, of dry copper-oxide rectifier has put a-c. testing on different basis; design and operation of rectifier operated instrument.

Metering

THREE-PHASE. The Metering of Three-Phase Supplies, O. Howarth. *Instn. Elec. Engrs.—Jl.*, vol. 69, no. 411, Mar. 1931, pp. 381-393 and (discussion) 393-403, 15 figs. Development of electricity supply during recent years has resulted in complexity in metering of three-phase supplies and has confronted meter engineer with task of achieving accuracy under difficult conditions; large bulk supplies are most complex and demand high standard of accuracy for commercial reasons; each additional complexity introduces additional source of error and paper deals with inaccuracies introduced by auxiliary apparatus and special equipment.

Motors

LOADS. Motors for High-Inertia Loads—II, R. E. Emerson. *Indus. Eng.*, vol. 89, no. 3, Mar. 1931, pp. 130-132, 2 figs. Consideration of energy stored in flywheel; use of high inertia in flywheels for handling peak loads while motor runs at full-speed.

MAINTENANCE AND REPAIR. Electric Motor Operation and Maintenance—II, G. H. Emerson. *Power Plant Eng.*, vol. 35, no. 7, Apr. 1, 1931, pp. 423-425. Methods of procedure in determining condition of machines; instruments used; overhauling and repair.

STARTING. Un nouveau démarreur automatique pour moteurs électriques (New Automatic Starter for Electric Motors). *Science et Industrie*, vol. 15, no. 205, Feb. 1931, pp. 85-87 and 92, 3 figs. New electrolytic starter of Rene Planchi Co. in Villefrance sur Saone is described; advantages and field of application are outlined.

TESTING. Tests of Rotating Electrical Apparatus for Electrical Characteristics, A. C. Roe. *Power Plant Eng.*, vol. 35, no. 6, Mar. 15, 1931, pp. 372-373. Practical discussion of proper methods to be employed in electric motor tests.

RAILROAD. Field Shunting and Modern Motor Design, L. B. Hewitt. *Elec. Ry. Bus and Tram Jl.*, vol. 64, no. 1596, Mar. 13, 1931, pp. 141-143, 3 figs. Metropolitan Electric Tramways carried out experiments several years ago, on their 40-hp. non-interpole motors, using field shunting with object of increasing top speed and improving acceleration; this was arranged by means of contactor which was energized on last notch of controller, but under control of specially designed relay which automatically prevented shunting coming into operations if conditions were such that current would rise above predetermined amount.

Comparaison du couplage série-parallèle et du couplage série permanent des moteurs compound dans les systemes à récupération (Comparison of Series-Parallel and of Permanent Series Coupling of Compound Motors in Regenerative Systems), F. Guery. *Revue Générale de l'Electricité*, vol. 29, no. 10, Mar. 7, 1931, pp. 381-385, 3 figs. Comparison of systems of Bacqueyrisse and Lièvre: study has bearing upon essential characteristics of motors and regarded from standpoint of dimensions, all other conditions remaining same; author points to importance of losses in series parallel system.

Networks

Fundamentals of the Medium Voltage Network, D. K. Blake. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 210-217, 17 figs. Modern a-c. low-voltage 120/208-volt network has brought out substantial economies, simplification, flexibility, and standardization involved in network principle; it is not generally recognized that network principle is applicable at medium voltage (4,000 volts) to residential and industrial areas having very low densities.

MAINTENANCE AND REPAIR. De l'organisation du controle permanent de la construction et de l'exploitation d'un réseau rural de distribution d'energie électrique (System for Permanent Supervision, Construction and Exploitation of Rural Distribution Network), L. Melot. *Revue Générale de l'Electricité*, vol. 29, no. 11, Mar. 14, 1931, pp. 429-437, 4 figs. Simple schematic and accurate number identification and index scheme for repairs, extensions, etc. for network system in continuous process of development; method has been successfully applied by author on networks of Loir-et-Cher district.

Ohmmeters

Ein neues Megohmmeter (New Megger), W. Jaekel. *V. D. I. Zeit.*, vol. 75, no. 11, Mar. 14, 1931, p. 316, 2 figs. New type of Siemens and Halske for measurement of insulating resistances of machinery equipment and cables up to many thousands of megohms; easy handling is featured.

Permeameters

TESTING. A Method for the Standardization of Permeameters at High Magnetizing Forces, R. L. Sanford. *U. S. Bur. Standards—Jl. Research*, vol. 6, no. 3, Mar. 1931, pp. 355-362, 6 figs. Apparatus suitable for testing of standard magnetic test bars to be used for standardization of magnetic permeameters with high magnetizing forces; criterion is given for determining when accurate values have been obtained; attention is called to necessity that standards shall be magnetically uniform.

Photoelectric Cells

Photoelectric Tube Increasingly Applied in Industry, J. W. Marshall. *Iron Age*, vol. 127, no. 13, Mar. 26, 1931, pp. 1012-1013, and 1067-1068, 3 figs. Operation principles and industrial application including application to problem of packaging machine design.

Construction, Operation and Characteristics of Photoelectric Tubes, L. R. Koller. *West. Soc. Engrs.—Jl.*, vol. 36, no. 1, Feb. 1931, pp. 15-25, 15 figs. Guide to intelligent selection to accomplish desired results.

Power Factor

Power Factor Correction in Industry, J. Murray. *Blast Furnace and Steel Plant*, vol. 19, no. 4, Apr. 1931, pp. 560-563, 8 figs. Simple method and equipment for power-factor correction in industrial plants.

Radio

AERIAL COMMUNICATION. European Aviation Radio, G. C. Gross. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 341-350 and (discussion) 351-352, 15 figs. Observations made on inspection trip over major European airways; aviation radio in Europe differs from aviation radio in United States in prevalent use of intermediate frequencies exclusively; it may be divided into communication from ground to plane and plane to ground; point-to-point communications in connection with traffic dispatching of aircraft; meteorological communication relating to safe flying conditions.

BROADCASTING. Ten Years of Broadcasting, C. W. Horn. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 356-376, 15 figs. Salient points in development of broadcasting during last decade are reviewed; it is shown that further improvement may be expected with more extensive introduction of higher powered transmitters.

DETECTORS. Grid Circuit Power Rectification, J. R. Nelson. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 489-500, 7 figs. Grid circuit power rectification is investigated by studying ideal rectifier and applying results obtained to case of tube rectifier; characteristic curves are used in this study to obtain optimum conditions for rectification and order of output voltage obtainable; conditions for minimum loading of circuit preceding detector are discussed.

ELECTROLYTIC CONDENSERS. Electrolytic Condensers for Radio Use, F. W. Godsey, Jr. *Electronics*, vol. 2, no. 4, Apr. 1931, pp. 596-597, 4 figs. Principles, equipment and its construction are described; electric and performance characteristics are given.

GENERATOR FREQUENCY. The Design of Radio-Frequency Signal Generators, J. R. Bird. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 438-451, 5 figs. Certain factors involved in designing signal generators free from stray voltage errors are considered; importance of accounting for all circuit details, particularly of wiring elements, is stressed; impedances of certain connections, particularly of output connections from generator to measured receiver, are shown to be important; shielding is considered in some detail.

MEASUREMENTS. Measurement of Resistance and Impedances at High Frequencies, J. W. Labus. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 452-460, 4 figs. It is shown that absolute value of unknown impedance, when put across end of transmission line, is simple function of ratio of currents, measured at beginning and end of transmission line; method has been tested out at wavelength of 21.8 meters, measuring resistance of number of grid leads and of decade box; a-c. resistance was considerably higher than labeled d-c. value; at same time shunted capacity across resistors has been measured and value have been obtained, which agree with expectations.

OSCILLATORS, PIEZOELECTRIC. Measurements of Temperature Coefficient and Pressure Coefficient of Quartz Crystal Oscillators, S. L. Brown and S. Harris. *Rev. Sci. Instruments*, vol. 2, no. 3, Mar. 1931, pp. 180-183, 2 figs. Method of measurement is used whereby variation in frequency of high frequency oscillator can be measured easily to fraction of part in million; audible different tone produced by harmonic of constant, high frequency oscillator and harmonic of second oscillator is compared to tone of variable, calibrated audio frequency oscillator.

OSCILLATION. Oscillation in Tuned Radio-Frequency Amplifiers, B. J. Thompson. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 421-437, 4 figs. Wide use of screen-grid tubes renders understanding of conditions for stability of tuned radio-frequency amplifiers important; in this paper relation between feed-back capacity and other circuit and tube parameters at threshold of instability is computed for one, two, three and four stages.

RESISTANCE. Resonant impedance and Effective Series Resistance of High-Frequency Parallel Resonant Circuits, H. Iinuma. *Inst. Radio Engrs.—Proc.*, vol. 19, no. 3, Mar. 1931, pp. 467-478, 11 figs. Example of application of method published in same journal, March 1930, p. 537, "A method of measuring radio-frequency resistance of oscillatory circuit."

SHORT WAVE. Radio Communication on Very Short Waves. *Engineering*, vol. 131, no. 3404, Apr. 10, 1931, pp. 482-483, 7 figs. Experiments are being made on wavelength of 18 cm. by International Telephone and Telegraph Laboratories, Inc., of Hendon, and Laboratories of "Le Matériel Téléphonique," of Paris, between St. Margaret's Bay, near Dover, and Cap Blanc, in France; apparatus used for this purpose, mainly developed by French engineers, consists of terminal equipment of normal design, which is connected to transmitter and receiver.

Railroads

ELECTRICAL ENGINEERING. Report of the Committee on Electricity. *Ry. Age (Daily Edition)*, vol. 90, no. 10B, Mar. 11, 1931, pp. 528-D44-45 and (discussion) 528-D45-46. Synopsis of matter presented before electrical section, Am. Ry. Assn., in October, 1930. Before Am. Ry. Eng. Assn.

ELECTRIFICATION. Thirty-Five Years' Experience with Heavy Electric Traction, S. Withington. *Ry. Age*, vol. 90, no. 12, Mar. 21, 1931, pp. 577-579. Satisfactory equipment has been found; conditions justifying electrification have been determined; need of unified system; era of expansion; early New Haven experience; important developments based on experience. Before New York Railroad Club.

INTERLOCKING SIGNALS. New Control System Used at Electric Interlocking on the Burlington, W. F. Zane. *Ry. Signaling*, vol. 24, no. 3, Mar. 1931, pp. 81-84, 6 figs. Independent control and indication circuits make for simplicity, reliability and freedom from grounds; signal layout plan; tower and power equipment at Downers Grove, Ill.; interlocking machine; outside construction; control and indication circuits; locking and signal circuits.

Remotely-Controlled Interlocking Solves Problem on C. and N. W., S. E. Noble. *Ry. Signaling*, vol. 24, no. 3, Mar. 1931, pp. 85-86, 4 figs. Extensive plant at West Nelson, Ill. controlled from desk levers in tower at another interlocking; track and signal plan of remotely-controlled plant; change in layout and circuit design; lever indication lights; outside construction.

OPERATION STATISTICS. Electric Railways Carry On in a Year Beset with Difficulties. *Elec. Ry. Jl.*, vol. 75, no. 4, Apr. 1931, pp. 197-200. Operating economies obtained in 1930 offset in large measure decreased revenues that were general; reports from 75 companies operating transportation lines in United States and other countries analyzed to give significant statistics; table of condensed financial reports of electrical railway properties 1930-1929.

Rectifiers

HIGH CAPACITY. High Power Rectifiers, J. W. Rissik and H. Rissik. *Engineer*, vol. 151, no. 3923, Mar. 20, 1931, p. 322. Editorial review of paper before Institution of Electrical Engineers, in which increasing field of application of rectifier is attributed to its economy on fluctuating loads, reliability under most severe operating conditions, rapidity with which it can be set to work, and fact that it is unaffected by disturbances on a-c. side; although discussion indicated that certain manufacturers are inclined to favor 600-volt rotaries, experiences on Continent and in America clearly show that engineers frequently specify rectifiers for 600 volts and similar pressures.

MERCURY-ARC. Mercury-Arc Power Rectifier Auxiliaries and Accessories, E. S. Waterman. *Gen. Elec. Rev.*, vol. 34, no. 4, Apr. 1931, pp. 228-234, 16 figs. Exhaust system; vacuum-measuring and regulating devices; ignition and excitation equipment; cooling system; thermal control devices; degassing equipment; resonant shunts and series reactor.

Refrigeration

The Young Engineer in the Refrigerating Industries, A. R. Stevenson, Jr. *Refrig. Eng.*, vol. 21, no. 4, Apr. 1931, pp. 256-258. Survey of possibilities for young engineer in refrigerating industries; classification of engineers by General Electric Co. together with qualifications and possibilities in following four classes: development, design, application and sales engineering.

Regulation

MACHINERY. Ueber die Reglung von Spitzenlast und Grundlastmaschinen (Regulation of Peakload and Base Load Machinery), W. Kieser. *Elektrizitaetswirtschaft*, vol. 30, no. 6, Mar. 1931, pp. 164-170, 13 figs. It is shown what unavoidable frequency fluctuations result in three-phase network from changes in load and how these fluctuations may be kept within narrow limits.

Remote Control

SHIP STEERING GEARS. Der sympathische Fernantried fuer Regel- und Umkehrorgane von Rudermaschinen (Electric Control of Ship Steering Gear), H. Kohrs. *Schiffbau*, vol. 32, no. 3, Feb. 1, 1931, pp. 60-64, 9 figs.; see also brief translated abstract in *Mar. Engr. and Motorship Bldr.*, vol. 54, no. 642, Mar. 1931, p. 116. Disadvantages of normal steering rod and chain control of rudder quadrant; electric installation by A. E. G., known as sympathetic distance control, is so arranged that rudder accurately and immediately follows each unit degree change in rotation of steering wheel; steering engine valve is controlled by geared motor supplied with current from Leonard motor-generator.

Resistors

DESIGN. Stromregelungen bei Laboratoriumsmessungen (Current Regulation in Laboratory Measurements), G. Hauffe. *Elektrotechnische Zeit.*, vol. 52, no. 11, Mar. 12, 1931, pp. 340-341, 4 figs. For exact adjustment of current readings, parallel dimensions of resistors is often required; range of regulation and dimensions of such equipment are discussed and curves for quick design are developed.

Rheostats

Theory of a Combined Series and Potentiometer Rheostat, J. R. Nielsen. *Rev. Sci. Instruments*, vol. 2, no. 3, Mar. 1931, pp. 184-186, 1 fig. Theoretical mathematical analysis pertaining to rheostat designed by Dodge and which permits rapid change from series to potentiometer connection, or vice versa, by simple closing or opening switch.

Sound Measurement

Mesure des intensités sonores par la méthode des scintillations (Measurement of Sound Intensities by Scintillation Method), F. Canac. *Physique et le Radium—Jl.*, vol. 2, no. 2, Feb. 1931, pp. 42-60, 10 figs. Theoretical analysis, measurements and results of experiments.

Spectrum Analysis

Energy Measurements in the Visible and Ultraviolet, F. Bendord and R. F. Howe. *Illum. Eng. Soc.—Trans.*, vol. 26, no. 3, Mar. 1931, pp. 292-301 and (discussion) 301-305, 6 figs. Three common ways of making energy analysis in visible and ultraviolet are photographic method, filter method and monochromator method; these three methods are not fully interchangeable and nature of source of energy often dictates which shall be used; inherent limitations of all three are discussed with reference to measurements of sunlight and some of common sources of light and ultraviolet radiation.

Substations

INDUSTRIAL. Industrial Plant Substations, O. H. Henschel. *South. Power Jl.*, vol. 49, no. 3, Mar. 1931, pp. 67-72 and 74, 9 figs. Notes on indoor and outdoor types of industrial plant substations; general layout and equipment design; typical installations; multiple transformer stations; combination stations; secondary substations.

LIGHTING. Outdoor Substation Lighting, H. E. Hutter. *Elec. Rev.*, vol. 108, no. 2781, Mar. 13, 1931, pp. 460-461, 5 figs. Principles of underlying provision of adequate illumination to meet requirements both of normal operation and emergency repair work; samples of lighting units to be used, design and construction and details are given.

Synchronizers

AUTOMATIC. Automatic Synchronizing Equipment. *Power Engr.*, vol. 26, no. 300, Mar. 1931, pp. 105-109, 12 figs. Principles of and apparatus for synchronizing a-c. generators automatically; Brown-Boveri apparatus for automatic synchronizing; Reyrolle system; performance curves and diagrams.

Transformers

AUTO. Auto-Transformers for Starting Induction Motors, A. Holt. *Power*, vol. 73, no. 13, Mar. 31, 1931, pp. 508-510, 3 figs. Although induction motors designed for starting on full voltage have come into general use, there are vast numbers in service that are started on reduced voltage; voltage supplied by auto-transformers; practical discussion of selection and care of electric equipment.

GROUNDING. Grounding Transformers, H. Fahnoe and E. G. Reed. *Elec. Jl.*, vol. 28, no. 4, Apr. 1931, pp. 226-230, 10 figs. On three-phase power system grounding transformer is frequently used not only to provide neutral ground connection, but also to limit to predetermined value current flowing during line-to-ground fault; notes on star-delta connected grounding transformers; interconnected-star grounding transformer; thermal protection of grounding transformers; equivalent kv. rating of grounding transformers; numerical examples.

INSTRUMENT. Current Transformers, G. W. Stubbings. *Elec. Rev.*, vol. 108, no. 2871, Mar. 13, 1931, pp. 462-463, 1 fig. Critical study of various methods of determining errors; vector relationships; absolute methods of testing; comparison methods of testing; elimination of detector errors; novel comparison methods.

Waves

TRANSIENT. Die Umbilding der Wellenform durch Kapazitaeten und Induktivitaeten bei durch Funken ausgeloesten Wanderwellen (Reshaping of Wave Form by Capacity and Inductance of Spark Generator Traveling Waves), W. Schilling. *Archiv fuer Elektrotechnik*, vol. 25, no. 2, Feb. 21, 1931, pp. 97-122, 21 figs. Voltage characteristic of waves in simple circuit; approximate equations for large breaking capacities; influence of capacity and inductivity in wave form and voltage.

ULTRA-SHORT. Sur la réflexion des ondes électromagnétiques (Reflection of Electromagnetic Waves), C. Gutton and G. Beauvais. *Académie des Sciences—Comptes Rendus*, vol. 191, no. 26, Dec. 29, 1930, pp. 1418-1420; see also translated abstract in *Experimental Wireless*, vol. 8, no. 90, Mar. 1931, pp. 143-144. Experiments with reflected ultra-short waves from 6 to 10 m. and results obtained.

Welding

HYDRAULIC TURBINES. Hydraulic Turbine Repaired by Electric Welding, C. R. Reid. *Power*, vol. 73, no. 12, Mar. 24, 1931, pp. 478-479, 3 figs. Badly damaged Francis-type runner of 20,000-hp. unit repaired at cost of only $2,274.

PIPE LINES. 1930 Piping Jobs Simplified by Welding. W. R. Wood. *Heat. and Piping Contractors Nat. Assn.—Off. Bul.*, vol. 38, no. 4, Apr. 1931, pp. 37-39, 9 figs. Advantages of welding as exemplified by Empire State and Cornell Medical Center installations.

SHEET STEEL. Sheet Metal Welding Formulae. *Sheet Metal Industries*, vol. 4, no. 11, Mar. 1931, pp. 984, 986, and 989, 3 figs. Up to present, literature of welding processes reveals almost complete absence of formulas; first attempt to obtain such laws carried out by D. Seferian; results of tests are shown in table and are also represented graphically.

SHIPBUILDING. Experiences with an Electrically-Welded Ship. *Engineering*, vol. 131, no. 3403, Apr. 3, 1931, pp. 460-461, 3 figs. Fullagar, now known as Shean, was launched in 1920; vessel has several times been aground and on each occasion, later examination showed keel and bottom plating to have stood severe conditions without ill effect; after more than 11 years of service it has been impossible to trace any undue corrosion in welded structure; experiences form remarkable demonstration of possibilities of electric welding in ship construction and valuable tribute to methods and materials of Quasi-Arc Co.

TRACKS. Welding Manganese Track Work, H. H. George. *Traction Shop and Roadway*, vol. 4, no. 3, Mar. 1931, pp. 77-80, 16 figs.; see also *Elec. Traction*, vol. 27, no. 3, Mar. 1931, pp. 125-127, 16 figs. Knowledge of, and adherence to fundamental requirements, found through experience, results in long life for track work reconstructed by welding; Cleveland's welding rules; frequent repairs to frogs handled quickly by welding; switch repairs that save money and prevent derailments.

Industrial Notes

Lamp Companies Merge.—Plans for a merger have been approved by the directors of the Hygrade Lamp Company of Salem, Mass., and the Sylvania Products Company and the Nilco Lamp Works, Inc., both of Emporium, Penn. Combined sales of these companies amounted to approximately $9,000,000 for the year 1930. The Emporium and Salem units each manufacture incandescent lamp bulbs and radio tubes. The electric lamp bulbs are manufactured and sold under a license agreement with the General Electric Company.

A New Rectifier.—A new line of heavy duty rectifiers has been announced by the B-L Electric Manufacturing Company, St. Louis, supplementing the small rectifiers which the company has produced for some years. These rectifiers are constructed entirely of metal plates without any moving parts and are of rugged construction. They are used to obtain low voltage direct current from the ordinary alternating-current lines and for this purpose require the use of small step-down transformers. Many applications exist for the use of such rectifiers in the fields of radio, sound-film equipment, signaling, alarms, industrial control, etc. B-L Electric Mfg. Company, 19th & Washington Avenue, St. Louis.

New G-E Plant Near Completion.—The new million dollar Cleveland wire works plant of the General Electric Company, which is being erected at South Euclid, on the outskirts of Cleveland, is rapidly nearing completion, according to E. J. Edwards, engineer in charge of plant construction for the incandescent lamp department. The new plant, which is to be devoted to the manufacture of filament wire, represents the largest arc-welding job ever attempted in the Cleveland territory. More than a thousand tons of structural steel are going into its construction. The building covers an area 493 feet in length by 320 feet in width. It will provide 185,000 square feet of floor space. Tentative production schedules call for a plant output of more than 300,000 miles of filament wire during the year 1932. The structure is scheduled for completion August 15 by the Austin Company, of Cleveland, who built the original Nela Park in 1912.

A New Power Filter Unit.—The Square D Company, Detroit, has announced the introduction of a power filter unit for supplying noiseless, non-pulsating, direct-current power from ordinary alternating-current circuits and applicable to telephone circuits, intercommunicating systems, public address systems, talking picture equipment and other sound producing apparatus. No auxiliary equipment is necessary. The new device is noiseless and has no moving parts. Square D Company, Detroit.

Installing Underground Cable.—By means of a special plow built by the General Electric Company, the plow being available for rental purposes, parkway or underground cable can be installed beneath sod and in locations where a minimum disturbance to the ground is desired. A reel of parkway cable is located at one end of the circuit run, and is mounted on supports so that it may unreel easily. The plow is connected to a tractor, and one end of the parkway cable is connected to the plow blade. It may be used to best advantage when installing parkway cable within the curb line of a street, around tree roots, poles, etc. The depth limit of the plow is 15 inches.

Trade Literature

Airport Lighting.—Catalog 218-FA, 30 pp. Describes a complete line of electrical equipment necessary for airport lighting. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Vitrohm Resistors.—Bulletin 507, 8 pp. Describes vitrohm resistors and rheostats for radio. Ward Leonard Electric Company, Mount Vernon, N. Y.

Carbon Brushes.—Catalog 12, 42 pp. Describes a complete line of standard and special brushes for motors, generators and synchronous converters. Boxill-Bruel Carbon Co., Columbia Park, Ohio.

Small Generator Units.—Bulletin 1908, 12 pp. Describes belt driven generators, turbine generator units, portable gas engine-driven power units and electric service plants up to 15 kw. Westinghouse Electric & Mfg. Company, East Pittsburgh.

Line Hardware.—Bulletin 5, 4 pp. Describes guying specialties, including guy hooks, eye nuts, curved ribbed washers, double guy blocks, Shull boltless guy clamps, and "pick-up head" anchor rods. Malleable Iron Fittings Company, Branford, Conn.

The Stenode.—Bulletin 1, 24 pp. Describes the "Stenode," for which the claim is made that it is by far the most selective radio receiver. Drawings of various circuits are included. The Stenode Corporation of America, Hempstead Gardens, L. I., N. Y.

Instruments.—Catalog F Part 2, 48 pp. Supplement to Part 1 of Catalog F. Describes all new General Radio instruments for electrical measurements at communication frequencies, and announces many important specification changes in the others. General Radio Company, Cambridge, A, Mass.

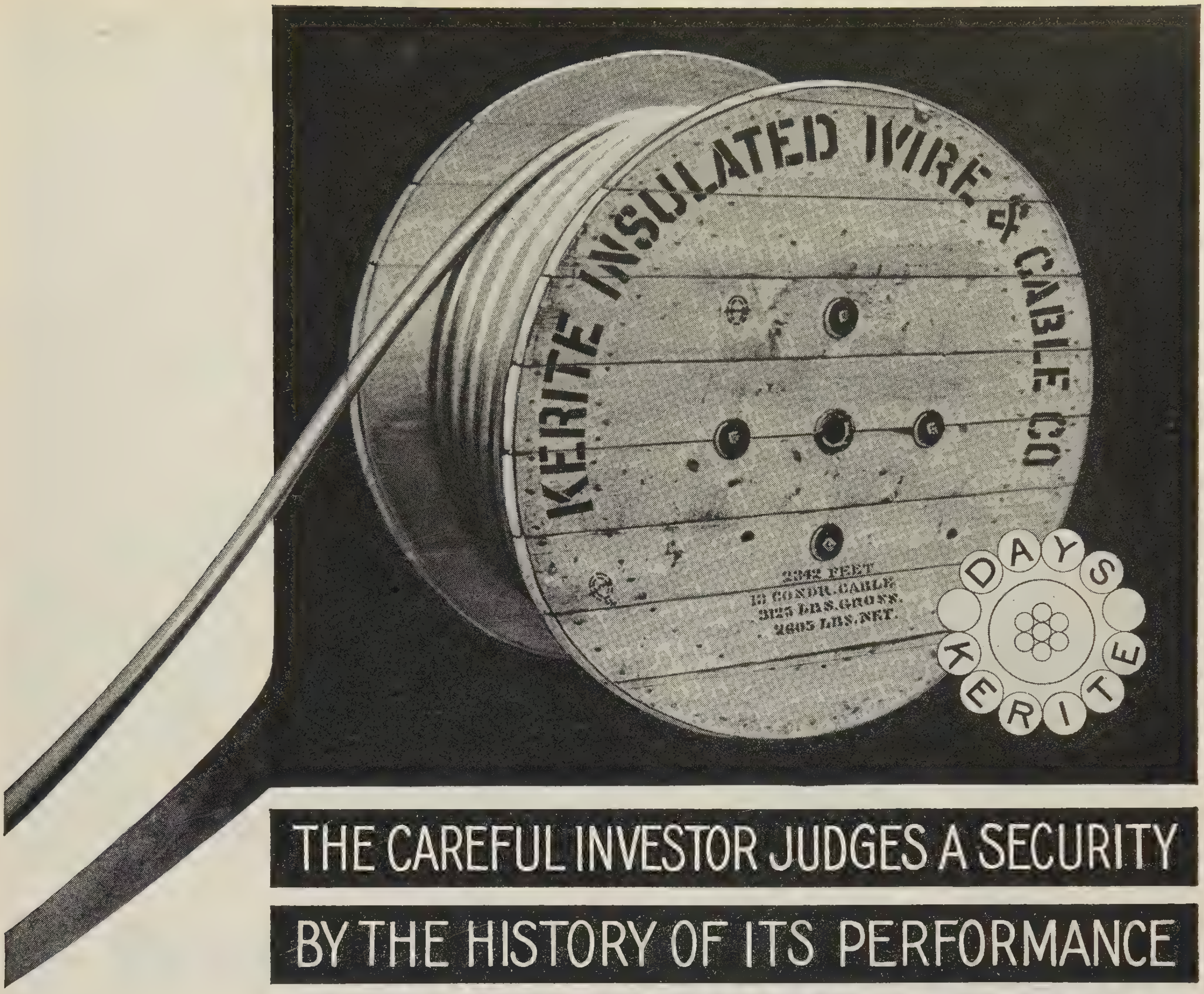
Circuit Breakers.—Bulletin 37, 16 pp. Describes Pacific Electric multi-break oil circuit breakers. These 69-kv. breakers incorporate many new features and improvements over former types. Pacific Electric Manufacturing Corp., 5815 Third Street, San Francisco.

Remote Control Cars.—Bulletin 1239, 12 pp. Describes automatic and remote control quarry cars which are controlled by one operator from a distant point. The idea of remote control is not entirely new, but the scheme described in the bulletin depends upon the use of alternating current, which has not heretofore been employed in such operation. The Atlas Car & Mfg. Co., Cleveland.

Manual of "Megger" Practice.—A pocket manual, 96 pp., treating in a comprehensive manner on the subject of electrical insulation and uses of insulation testing instruments. It includes valuable data on the characteristics of insulation and suggests how and where to look for insulation defects in electrical equipment. Sixty-seven illustrations are included. James G. Biddle Company, 1211 Arch Street, Philadelphia.

Lightning Arresters.—Bulletin 313, 64 pp. Describes a complete line of lightning arresters, including Keystone crystal valve lightning arresters for high and low voltage a-c. service and for low voltage d-c. service; Garton-Daniels lightning arresters for low-voltage a-c. and d-c. service and for standard and high voltage d-c. railway service; Keystone and Protex radio lightning arresters; and ground fittings. Electric Service Supplies Co., 17th & Cambria Streets, Philadelphia.

Motors.—Bulletin 165. Describes seven distinct types of squirrel cage motors, comparing them as to their starting torques, starting currents and cost. Speed-torque curves and tables make a thorough comparison of the seven types to enable a proper selection for different applications. The bulletin also describes construction details, and has a section on "mechanical variations" in which roller bearings, totally-enclosed, fan-cooled, vertical and three-bearing motors are discussed. There is also a section on multi-speed motors and control equipment. Wagner Electric Corporation, 6400 Plymouth Avenue, St. Louis.

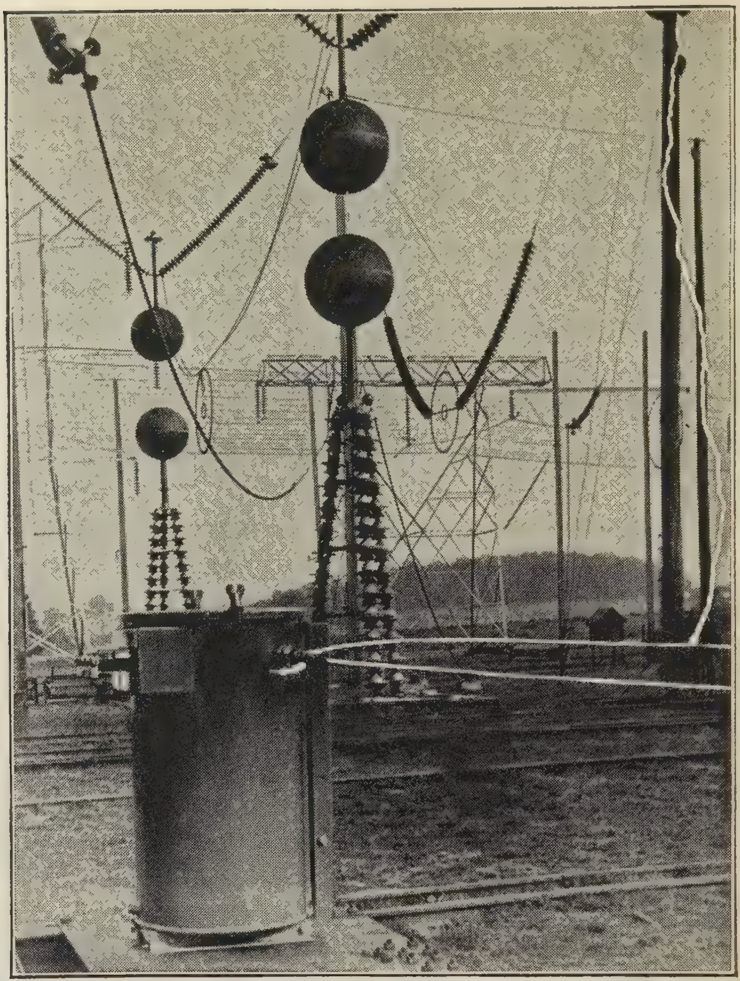


THE CAREFUL INVESTOR JUDGES A SECURITY
BY THE HISTORY OF ITS PERFORMANCE

KERITE

IN THREE-QUARTERS OF A CENTURY OF
CONTINUOUS PRODUCTION HAS ESTABLISHED
A RECORD OF PERFORMANCE
THAT IS UNEQUALLED IN THE HISTORY OF
INSULATED WIRES AND CABLES

THE KERITE INSULATED WIRE & CABLE COMPANY INC
NEW YORK CHICAGO SAN FRANCISCO



2300 volt Allis-Chalmers Type SB transformer being subjected to artificial lightning impulse of 1,500,000 volts.

Three years service

Repeated Tests by Artificial Lightning

and

Not one has failed—

Between 4000 and 5000 Type SB transformers have been shipped to various points in the United States during the past three years.

Not one of these transformers has failed from any cause.

This operating record is due to features of construction which are built into Allis-Chalmers type SB transformers.

1. Cable paper insulation treated by a special process developed by Allis-Chalmers research chemists.

2. Detachable stud bushings having a definitely co-ordinated flashover value with respect to the coil insulation.

3. McCoy low temperature impregnation (anti-ionization) process.

SB transformers also include the following additional features:

1. Non-Siphoning bushing construction.
2. Copper alloy steel tanks, D. C. arc welded.
3. Pressed steel covers.
4. Skid cradle suspension construction in connection with hot dipped galvanized hangers.
5. Low core and copper losses.
6. Core and coil structure supported against side shifting by T rails and improved mechanical lock.
7. Transformers can be shipped completely filled with oil ready for service.

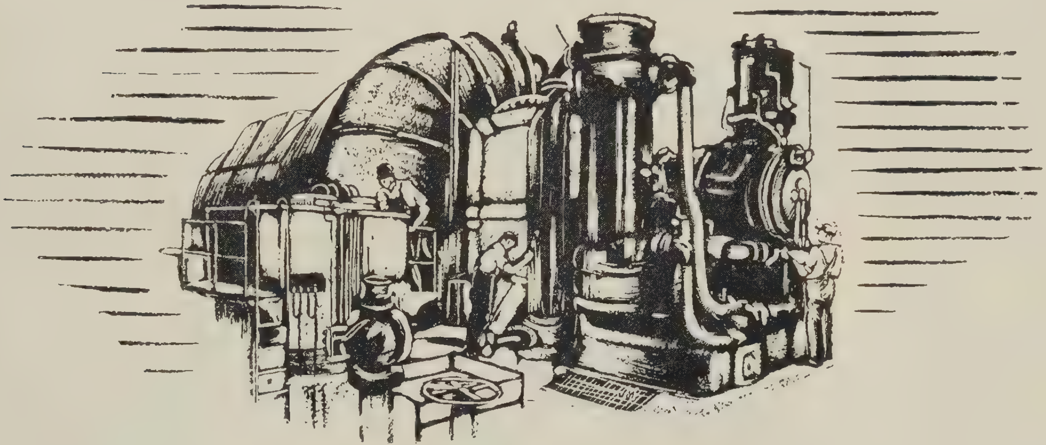
These transformers cost very little more than transformers not possessing these important advantages.

Write our nearest district office for details.

ALLIS-CHALMERS

Allis-Chalmers Manufacturing Company, Milwaukee

THERE IS NO SUBSTITUTE FOR TURBINE SAFETY



In today's, high-speed, high-temperature turbine units, effective lubrication is most important and the demands upon the lubricant more exacting than in perhaps any other type of moving equipment.

There is no substitute for safety. There is no substitute for the feeling of complete confidence that the lubricant in your turbine system is actually doing its work every minute of the time—surely and effectively.

Use Texaco Regal Oils. These unusual turbine lubricants are refined by special Texaco processes that give them exceptional qualities. With Texaco Regal Oil, bearing temperatures are generally lower, and troubles from sludging, emulsification and acidity, even after years of service, are practically unknown. And you can depend on Texaco Regal Oils for their rigid uniformity, always.

Write The Texas Company on any question of lubrication. Texaco Lubrication Engineers are at your call—and the systematic laboratory analysis provided for every user of Texaco Regal Oils insures the certainty of the very highest in effective, safe lubrication.

TEXACO LUBRICANTS

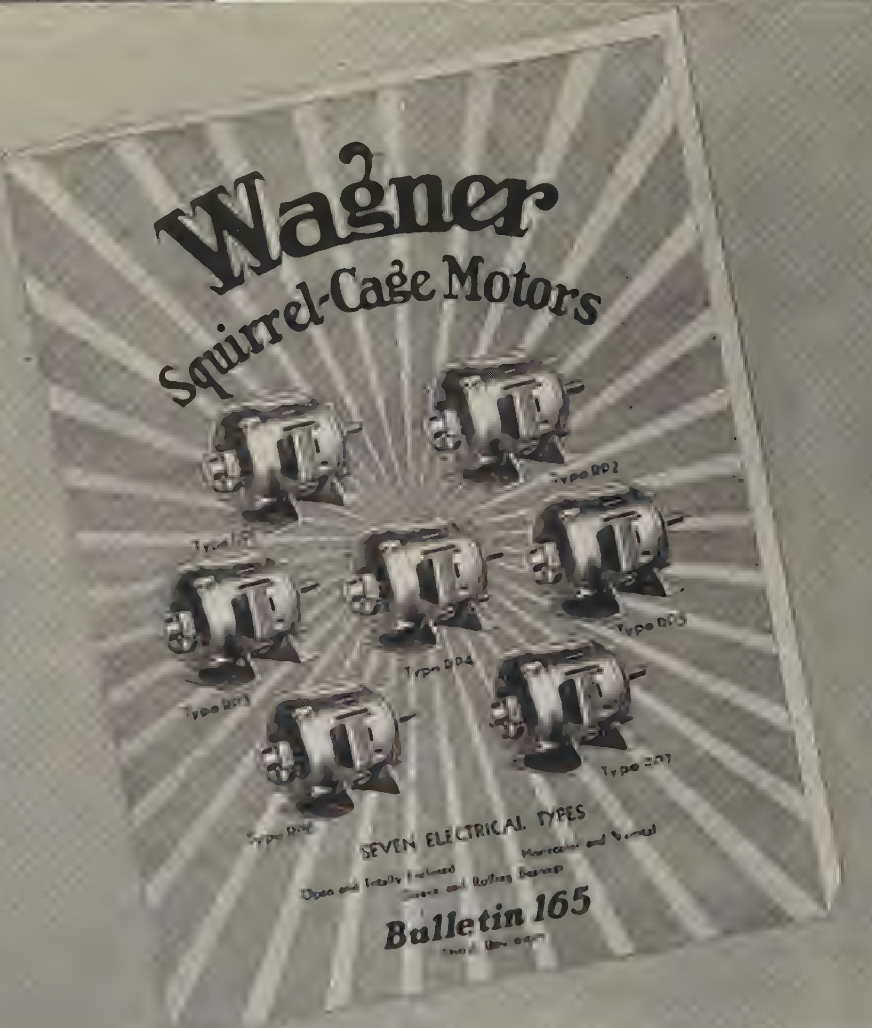
THE TEXAS COMPANY
135 East 42nd Street, New York City

Write for this new bulletin

Just off the press—a completely revised edition of Bulletin 165 fully describing Wagner's seven types of squirrel cage motors, explaining in detail how they differ from one another, how they are made, how to apply them to fit the job, etc. In addition there are sections on rolling bearing, totally-enclosed fan-cooled, three-bearing, multi-speed and vertical motors; Multi-V-Drive, the well-known product of Worthington and Goodyear recently added to the Wagner line; and control equipment. » » » Ask for a copy of this bulletin; just sign and mail the coupon.

CONTENTS

- RP1 Motors
- RP2 Motors
- RP3 Motors
- RP4 Motors
- RP5 Motors
- RP6 Motors
- RP7 Motors
- Stator Construction
- Rotor Construction
- Frame Construction
- Bearing Construction
- Roller Bearing Motors
- Totally Enclosed Fan-Cooled Motors
- Multi-Speed Motors
- Three-Bearing Motors
- Vertical Motors
- Multi-V-Drive
- Control Equipment



SIGN AND MAIL THIS COUPON

WAGNER ELECTRIC CORPORATION,
6400 Plymouth Ave., St. Louis, Mo.

Please send copy of the completely revised Bulletin 165 on Squirrel Cage Motors.

NAME & POSITION ______________________

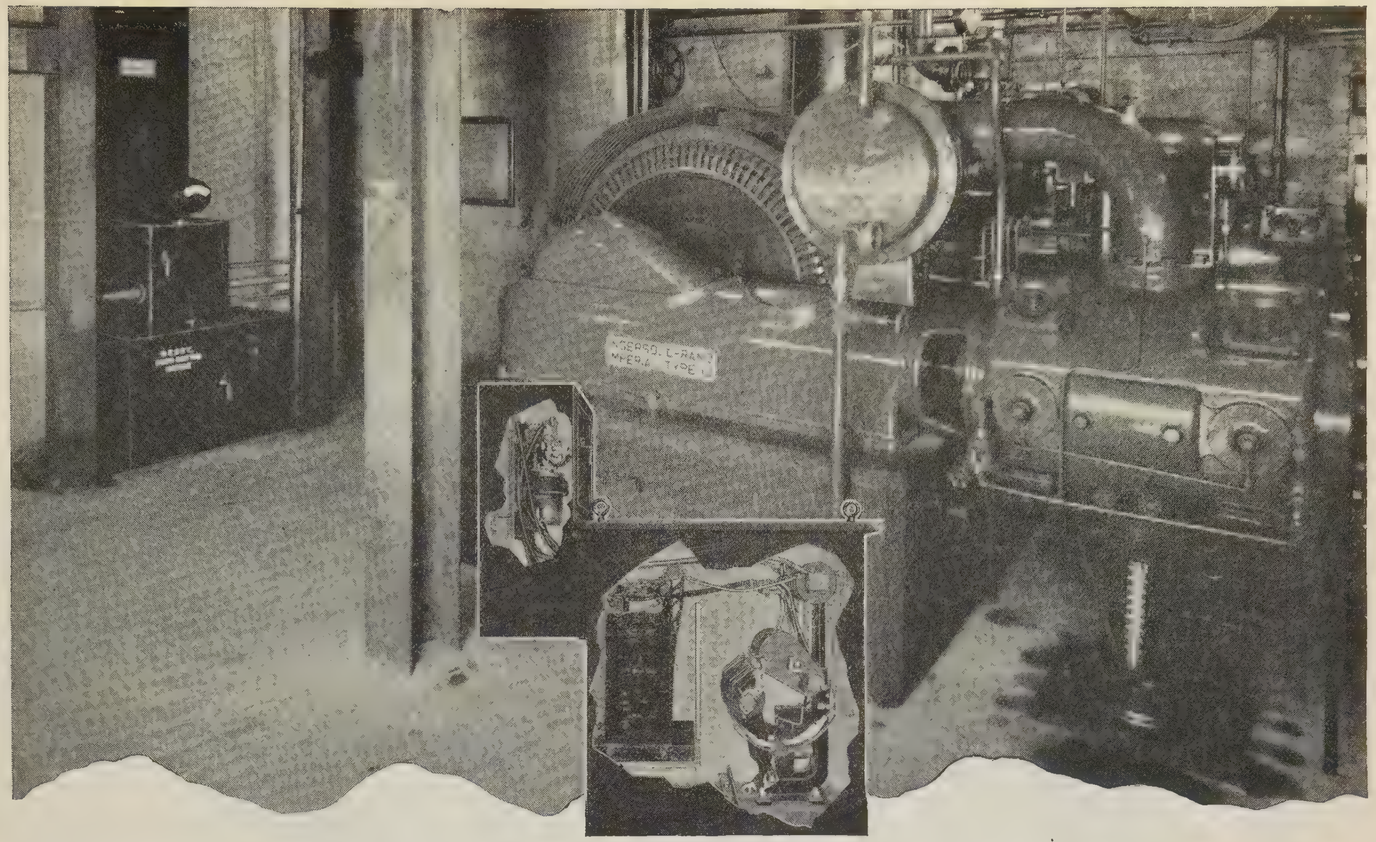
COMPANY ______________________

ADDRESS ______________________

Wagner Electric Corporation
6400 Plymouth Avenue, Saint Louis, U. S. A.

MOTORS TRANSFORMERS FANS
LOCKHEED HYDRAULIC BRAKES

L231-4X



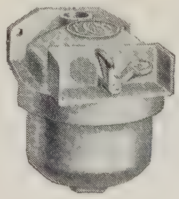
Type ZHS Synchronous Starters

—there is no other starter built like them

THE above illustration shows the installation of an EC&M Type ZHS Across-the-Line Starter which controls a 150-h.p., 2300-volt Synchronous Motor driving an air compressor.

This is a completely wired and totally enclosed unit, consisting of a standard Type ZHS Starter (shown in insert), to which has been added an automatic field switching panel enclosed in a steel cabinet and welded to the back of the starter tank. This self-contained unit provides a dust-proof, vapor-proof and shock-proof installation that may be mounted in any dusty or explosive atmosphere with perfect safety.

There is no other starter built like the EC&M Type ZHS Starter. It is not an adaptation of a switchboard circuit breaker, but is of a design specifically built for controlling high voltage motors. It consists of a high voltage contactor of very sturdy mechanical construction with high arc-rupturing capacity. Working parts are few in number and are totally oil-immersed, insuring that the starter is always ready for operation at any time whether it is out of service for a few minutes or for several months. Bulletin 1062-J gives a complete description. Write for a copy.



BRAND NEW—Type EO Explosion-Proof Push Button for use as push button stations for automatic motor starters and for control of lighting circuits. Described in Bulletin 1105-J, just off the press.

THE ELECTRIC CONTROLLER & MFG. CO.

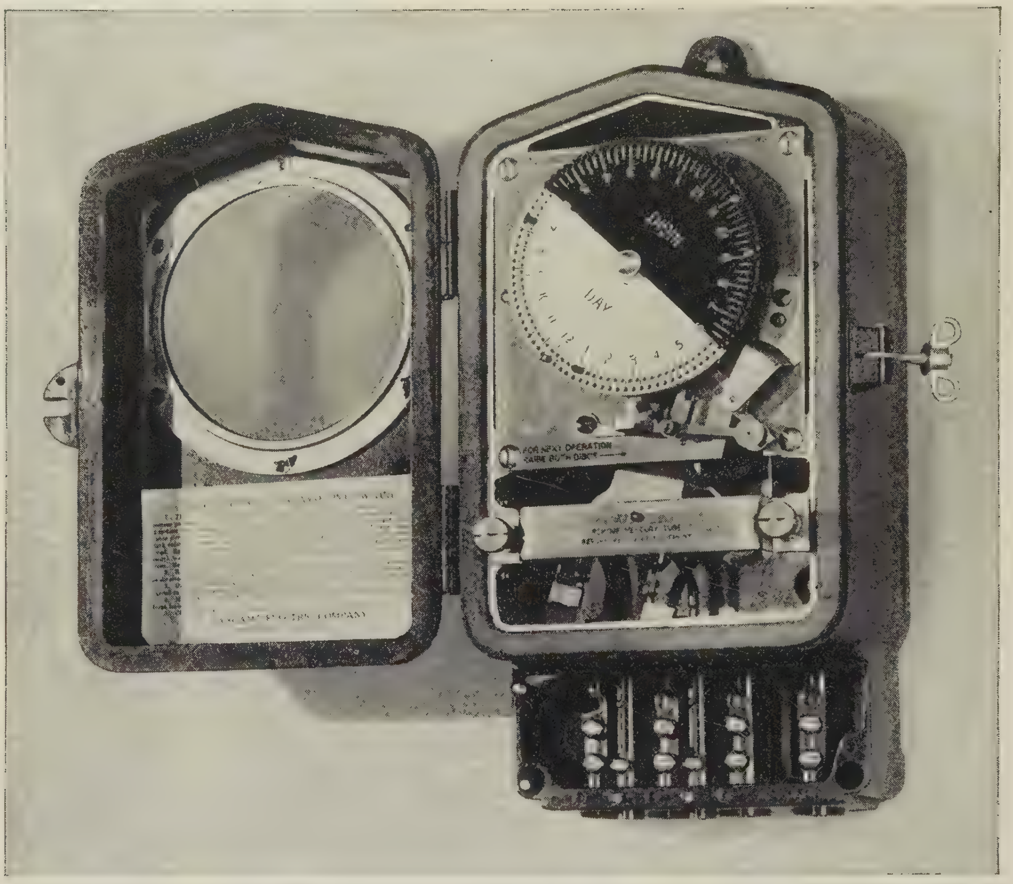
NEW YORK-50 CHURCH ST.
CHICAGO-CONWAY BLDG.
DETROIT-DIME BANK BLDG.
BIRMINGHAM-BROWN-MARX BLDG.
CINCINNATI-1ST NATIONAL BANK BLDG.
ST. LOUIS-6926 MARQUETTE AVE.

CLEVELAND, OHIO

LOS ANGELES-912 E. THIRD ST.
HOUSTON-P.O. BOX 4182
TORONTO-REFORD BLDG.

PHILADELPHIA-WITHERSPOON BLDG.
PITTSBURGH-OLIVER BLDG.
SAN FRANCISCO-CALL BUILDING
MONTREAL-CASTLE BLDG.
TULSA-COMMERCIAL BLDG.
SEATTLE-2207-1ST AVE. SO.

SANGAMO TIME-SWITCHES



ACCURATE TIME....ELECTRIC WINDING
MODERATE COST....LOW UPKEEP

The Sangamo Time-Switch is the product of combined facilities of two American manufacturers—each a leader in its field—Sangamo, makers of Meters, and Hamilton, manufacturer of the "Watch of Railroad Accuracy."

The Sangamo Time-Switch embodies these features:

1... Accurate dependable time... insured by the standard Sangamo clock-movement with Hamilton 11-jewel escapement having a micrometer adjustment, and fully protected by dust-cap.

2... Electric Winding... The switch mechanism is operated by a clock-mainspring, kept wound by a Sangamo motor which is continually in circuit. Because of ample reserve power, the switch is unaffected by current interruptions.

3... Mercury tube contacts of latest design, shown by tests to be absolutely dependable in service.

4... Independent of frequency or voltage variations.

5... Made for either a. c. or d. c. operation.

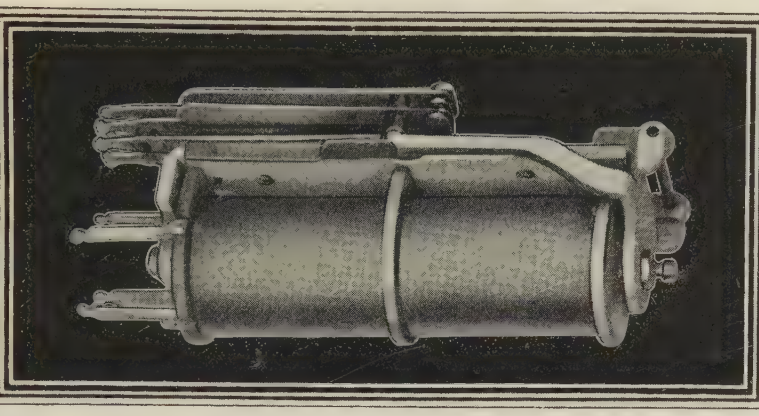
6... Low maintenance cost... simple, sturdy design assures trouble-free operation. All parts interchangeable.

For medium-priced installations as well as costly ones, wherever a sturdy and thoroughly dependable time-switch is required... specify Sangamo. Available with meter terminal base or conduit-connected base.

Write for descriptive folder giving complete details.

SANGAMO ELECTRIC COMPANY • SPRINGFIELD, ILLINOIS

STROWGER RELAYS



For Every Remote-Control Operation

The relays and remote-control switches used in the Strowger Automatic Telephone System are known among telephone engineers the world over for their accuracy and durability under the severe stresses of daily use. They are the result of intensive development and constant improvement to meet the rigid requirements of telephone operation.

The reliability, long life and versatility of these devices have led to an increasing demand from the electrical and manufacturing industries for their use wherever there is need for communication or remote-control over wires. New uses are being found for them almost daily.

The Strowger engineering staff invites correspondence regarding the adaptation of Strowger relays or Strowger switches to your specific needs and will gladly cooperate in suggesting suitable types. An inquiry involves no obligation on your part.

Write for These Bulletins

We have compiled several interesting bulletins, describing Strowger products, which are now available for distribution. We shall be glad to forward to you, without charge or obligation, those in which you are interested. Use the coupon below.

TYPES OF STROWGER RELAYS

- "Telephone Type" Relays
  - Quick Acting
  - Slow Acting
  - Double Wound
  - Mechanical Locking
  - Pulsing
  - Micrometer Adjustment
  - Midget
- A. C. Relays
- Polarized Relays
- Voltage Control Relays
- Supersensitive Relays
- Multiple Contact Relays
- Stepping Relays
- Oil Dashpot Relays
- Electric Counters

Engineered, Designed and Manufactured by

Automatic Electric Inc.

Factory and General Offices:

1031 West Van Buren Street, Chicago, U. S. A.

SALES AND SERVICE OFFICES:

Atlanta Boston Cincinnati Cleveland
Detroit Kansas City, Mo. Los Angeles New York
Pittsburgh St. Paul Washington, D. C.

ATTACH TO YOUR LETTERHEAD AND MAIL TO

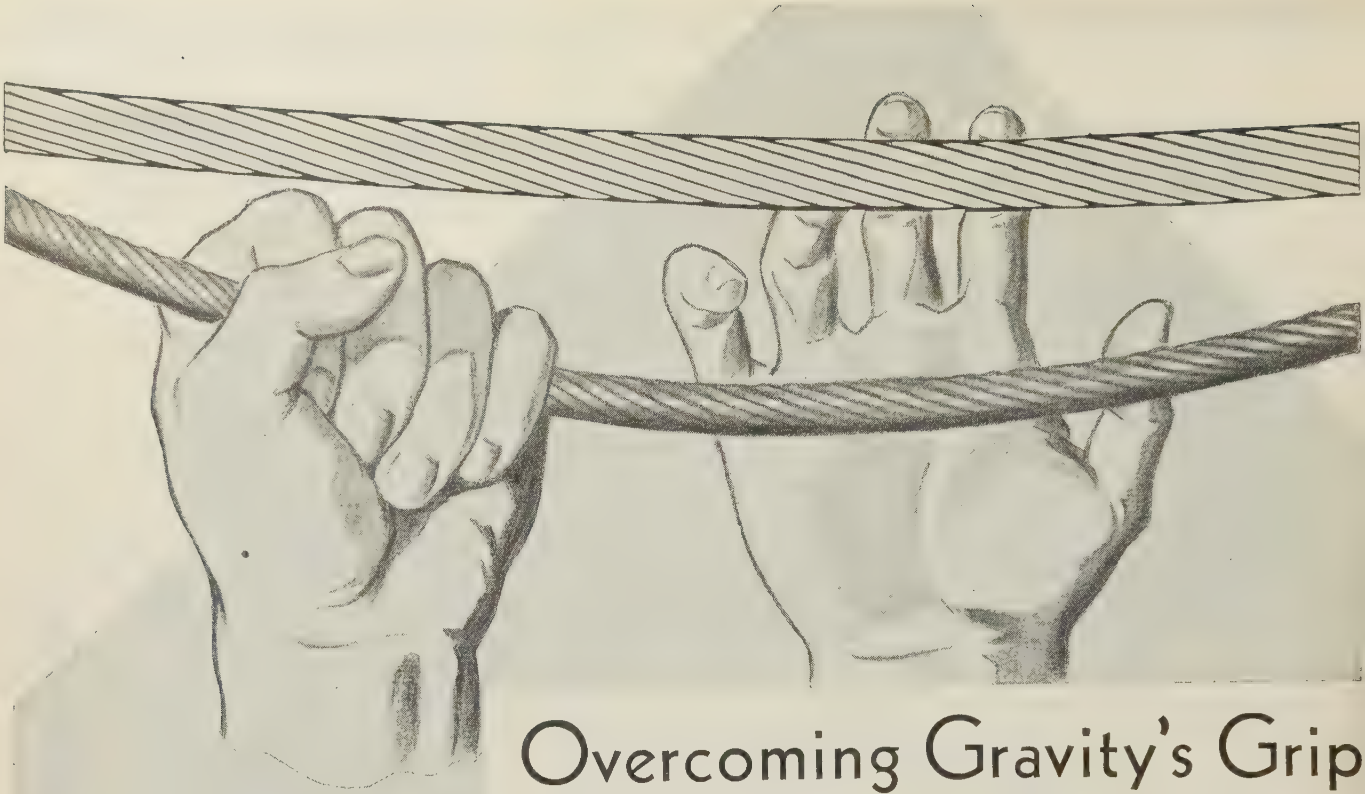
AUTOMATIC ELECTRIC Inc., 1031 W. Van Buren St., Chicago

Please send us bulletins on:

☐ Relays, Remote-Control Switches and Signal Accessories.
☐ Private Dial Telephone Systems.
☐ Fire-Alarm Systems.
☐ Multiple Time-Recorders.

Name ....

Position ....



Overcoming Gravity's Grip
A.C.S.R. permits longer spans
—needs fewer towers

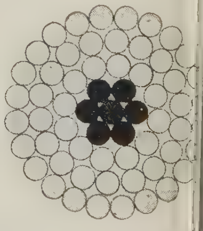
ALCOA
A.C.
ALUMINUM
O.A

For a given conductivity, A.C.S.R., being ⅓ lighter and ⅓ stronger than other commonly used cable, permits flatter sags and longer spans—hence requires fewer towers; or with this light, strong cable you can use lower structures for the same span. Alternatively you can secure a higher factor of safety in the same span with the same sag.

The steel core of A.C.S.R. provides great strength, and its Alcoa Aluminum strands combine light weight with high conductivity. Result—dead-load of wire reduced to the practical minimum, an a high margin of safety obtained.

Several types of Alcoa Aluminum Cables are available. A.C.S.R for high or low voltage transmission; for messenger-feeder for railroad catenary. Bare and insulated A.C.S.R. for rura and urban distribution lines and many other services. Bare and insulated all-aluminum cable for electric street railway and industrial feeders.

A representative will be glad to call and discuss the advantages of A.C.S.R. for any installation that you may have in mind. Address ALUMINUM COMPANY *of* AMERICA; 2448 Oliver Building, PITTSBURGH, PENNSYLVANIA.



ALUMINU
CABLE STE
REINFORCE

ALCOA ALUMINU

Public Relations and Electrical Theories are *"Sisters under their Skins"* *

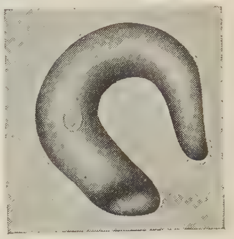
THE skilful transmission line designer and the highest officials of power organizations are in complete agreement in their keen desire to protect public good-will by reducing service interruptions to the irreducible minimum. However, to the line designer the fact that "it requires from two to four times the voltage to form an arc between spheres as compared with points, equally separated", states a principle of good design—an abstract principle which, when violated, not infrequently proclaims itself in concrete flashovers. vivid line-outages, and disturbed public relations.

Therefore, the experienced line designer is quick to observe both the violations as well as the applications of the spherical-principle in every piece of equipment which he may be called upon to consider. He well sees the spherical-principle applied at every possible point throughout the design of the O-B line of hardware. He discerns it in the broad curves, the rounded corners, the spherical surfaces—in the absence of sharp edges, acute angles and projecting points which invite flashovers. The experienced designer perceives that at no point is the spherical principle violated except where mechanical functions or structural necessities take precedence.

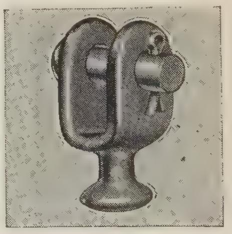
Hence the wide preference for O-B hardware among transmission line designers is not without reason. It is soundly based in the proved principles of best design, in the experienced freedom from flashovers, line-outages and enraged public opinion which result. Power company officials also recognize that good public relations and correctly applied electrical theories are "sisters under their skins".

OHIO BRASS COMPANY, MANSFIELD, OHIO
Canadian Ohio Brass Company Limited, Niagara Falls, Canada

● **O-B Suspension Eyes** for attaching suspension insulators to towers. Made of drop forged steel, hot-dip galvanized; with standard size ball socket connection in six sizes; five with round eye holes from $\frac{11}{16}$ inches to $1\frac{1}{4}$ inches, and one with an oval hole 1 inch by 2 inches. For detail drawings and catalog numbers, refer to pages 194 and 195 of O-B Catalog No. 20.

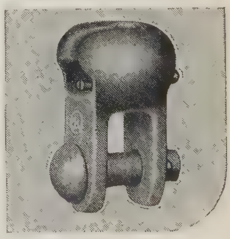


● **O-B Suspension Hooks** for attaching suspension insulators to towers. Made of drop forged steel, hot-dip galvanized. The opening in the hook shown is closed by the insulator cap, thus preventing unhooking after installation. The same hook is also made with two sizes of holes for clevis pin. Additional details and catalog numbers on page 196 of O-B Catalog No. 20.



● **O-B Suspension Clevises** for use in place of hooks and eyes for attaching insulators to towers. Also used to change from clevis type to ball and socket type insulators; permits use of mixed strings with ball and socket type insulators at the bottom of the clevis string. Drop forged steel, hot-dip galvanized, in three sizes: 1, $1\frac{9}{16}$ and $2\frac{9}{16}$-inch clevis yokes. Additional details and catalog numbers on pages 198 and 199 of O-B Catalog No. 20.

● **O-B Ball and Socket Clevis** can be used for attaching any clamp having an eye to the center pin of ball and socket type suspension insulators. Malleable iron, hot-dip galvanized, brass cotter pins. Diameter of bolt is $\frac{5}{8}$-inch; $\frac{13}{16}$-inch opening for clevis attachment. Detailed information on page 203 of O-B Catalog No. 20.



1411H

Ohio Brass Co.

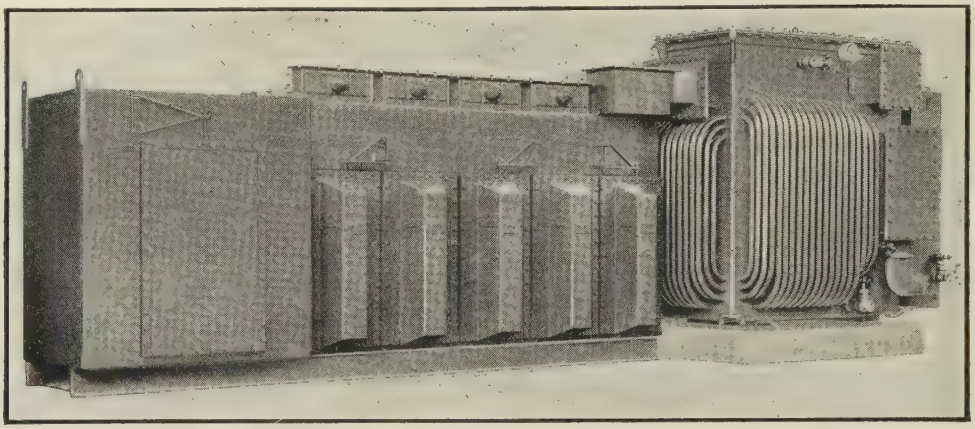
NEW YORK PHILADELPHIA PITTSBURGH BOSTON CHICAGO CLEVELAND ST. LOUIS ATLANTA DALLAS LOS ANGELES SAN FRANCISCO SEATTLE

PORCELAIN INSULATORS
LINE MATERIALS
RAIL BONDS
CAR EQUIPMENT
MINING MATERIALS
VALVES

---

*The Colonel's lady and Judy O'Grady are sisters under their skins.—Kipling.

Standardized Vault Unit for Primary Network System



Transformers, regulating equipment, switchgear, meters---all in one compact, coördinated unit

System planning can be simplified and ultimate costs reduced by adoption of the primary network system and the use of standard G-E network vault units.

With this complete, fully assembled unit, installation consists only of building a vault, lowering in the equipment, and connecting the incoming and outgoing cables. Engineering, construction, and purchasing are simplified. Deliveries can be timed to facilitate transportation and reduce storage.

IMPORTANT FEATURES

The complete unit is submersible, weighs less than 25 tons, and can be installed in a vault 30 by 9 by 11 ft., with ample room for inspection and maintenance.

The transformer, rated 1500 kv-a. self-cooled (provision for 2000 kv-a. with forced-air cooling), is equipped with automatic load ratio control of unique design, providing in a very simple and economical manner for voltage regulation.

Each oil circuit breaker, of the elevating type with motor-operated mechanism, is in an individual compartment. Each breaker can be lowered to the disconnected position without opening the door of the breaker compartment.

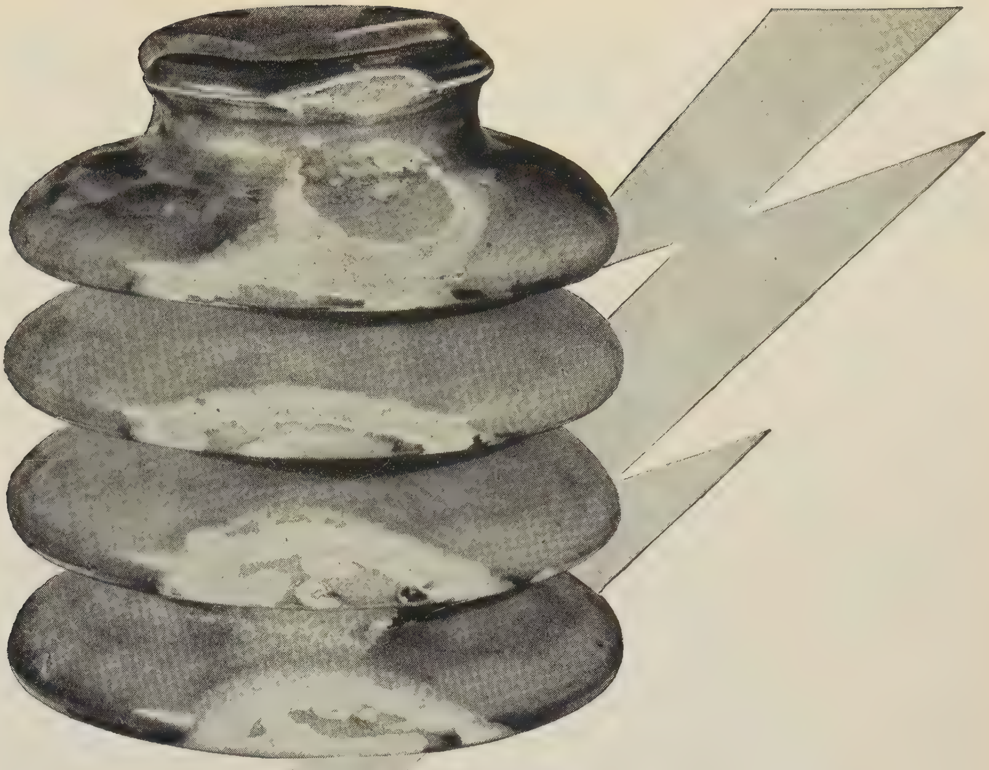
Relays, meters, and control equipment are in a separate compartment to facilitate maintenance and increase reliability.

Bus and current transformer compartments are filled with insulating compound of high dielectric strength. Unusually liberal design factors provide high insulation strength and current-carrying capacity. Atomic-hydrogen welding assures water-tight joints.

95-875

GENERAL ELECTRIC

JOIN US IN THE GENERAL ELECTRIC PROGRAM, BROADCAST EVERY SATURDAY EVENING ON A NATION-WIDE N.B.C. NETWORK



So it took the 7500 amperes

A line of the Gary Heat, Light and Water Company, struck by lightning, suffered a flashover calculated at 7500 amperes or more. The conductor burned down.

Of the Lapp No. 5842 Fog Type Insulators on the line two were flashed. One is shown in this unretouched photograph. Both Insulators, after test, proved sound electrically—and sound mechanically except where the glaze was melted off. Both, if put back into service, would probably have endured indefinitely.

This stability is typical of Lapp Fog Type Insulators. The short, sturdy petticoats don't rip away. They withstand an unusual amount of thermal punishment. Even if unexpectedly severe arcing should destroy one or more petticoats, the original efficiency, only slightly reduced, will hold the line in service. Rocks and bullets find Lapp Fog Type Insulators equally resistant.

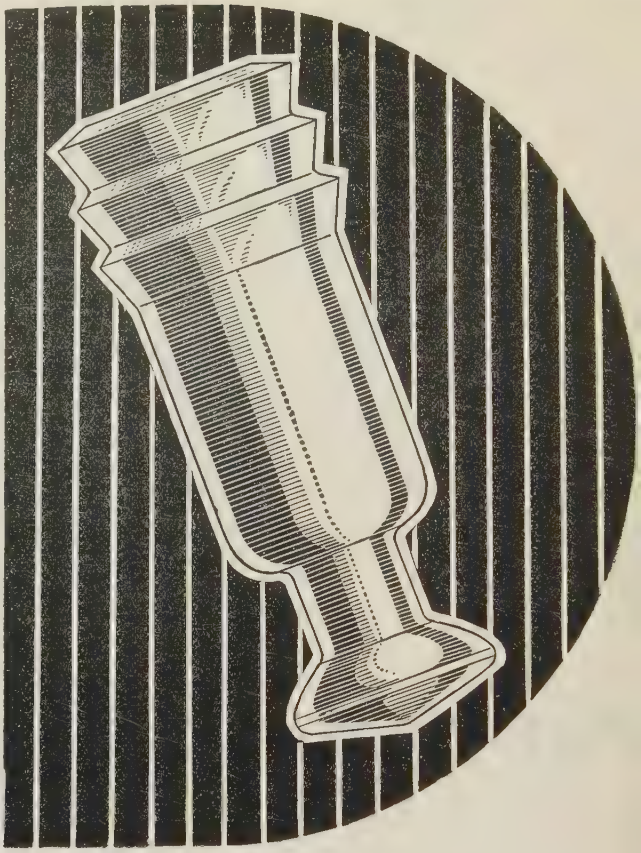
Lapp Fog Type Insulators are always better and for several voltages actually less expensive.

LAPP INSULATOR CO. INC **LAPP INSULATORS** **LE ROY · N.Y. · U.S.A.**

"....Is the design of the pin important?"

"It most certainly is. First, let me tell you something that few people realize. The pin hole of any suspension insulator is filled along its entire length with a combination of steel and cement. These materials having the same co-efficient of expansion, you can see that regardless of the size or shape of the pin the effect of thermal changes will be the same. Of course, provision is made in any modern insulator to eliminate the hazard of damage through expansion and contraction.

The pins used in our suspension insulators are scientifically designed to give the most efficient load distribution and are accurately turned from specification copper-bearing steel. This is why on test M & E and ultimate values are almost invariably identical. Instead of making the strength of the cement the determining factor the Locke pins utilize every part of the insulator. This distribution of duty—"balance" if you like—accounts for the 18,000-lb. rating of our standard suspension insulator.



And you might remember that this same pin design has been used in all suspension insulators manufactured by Locke for the past sixteen years, during which time there have been no failures."

LOCKE ▸ ▸ ▸
PORCELAIN
INSULATORS

LOCKE INSULATOR CORPORATION • • • • BALTIMORE, MARYLAND

HOW TO ECONOMIZE IN BUYING POTHEADS

STANDARDIZE
ON
G&W

AT THIS MOMENT, from G&W's stock you have your choice of three thousand five hundred different kinds of potheads.

G&W has a staff of distribution specialists ready to recommend a pothead in exact conformation to your own layout scheme.

Why not standardize on G&W?

You can save much time, effort, and expense.

Orders, reorders, replacements, and repairs are made with ease.

Here is a practical example of economies effected by standardization. Because of a change in substation layout, it was advisable to use potheads of another type. It was thought that the old potheads would be a complete loss. But G&W furnished several new lids, a new body, and the change was made at less than one fourth the original estimate.

Because of G&W interchangeability, because potheads are available on short notice for your every need, because G&W has had twenty five years of concentration and specialization on the application, design, and manufacture of potheads, — G&W is unusually well qualified to economically handle your cable terminal requirements from beginning to end.

STANDARDIZE ON G&W

Be sure to order your copy of "The Underground Systems Reference Book" from N. E. L. A. Headquarters, New York.

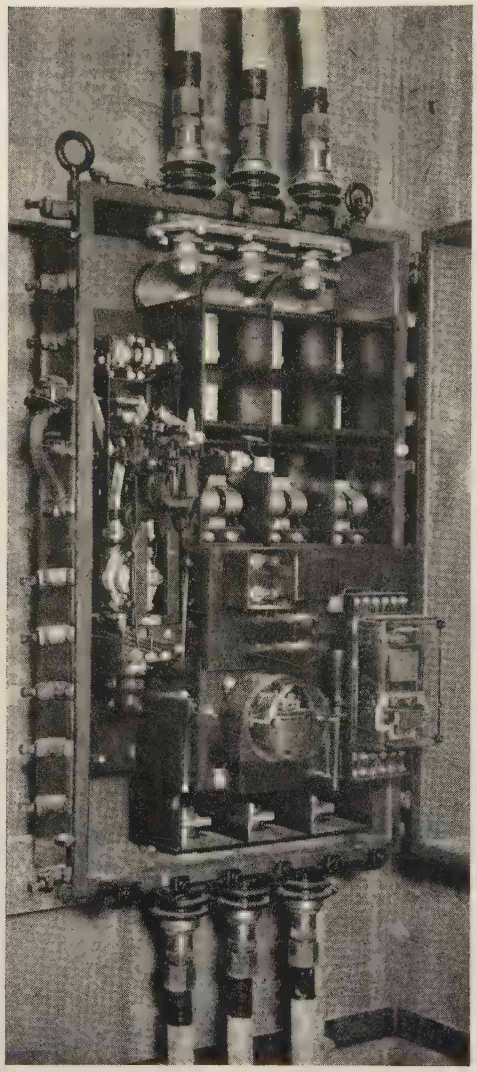
Potheads · Subway Boxes · Cable Terminal Devices · Automatic Transfer Switches

G&W Electric Specialty Co.

7780 Dante Avenue, Chicago · Representatives in Principal Cities

NET WORK
DOSSERTS

Note the Dossert Type F Stud Connectors connecting cables to studs at top and bottom of protector box.



DOSSERTS used to connect 2,000,000 C.M. single conductor cables to 1½ inch copper studs on 1600 ampere, 250 volt submersible type A.C. network protector.

THE engineer on A.C. net work equipment has found Dosserts a help toward substantial construction.

On the Network Protector above, photographed on the lines of the Milwaukee Railway & Light Company, the Dosserts, connecting cable to studs, have provided not only proper electrical connection but also a fine appearance.

On all wiring work—connecting cables, stranded or solid wires, rods and tubing, there are Dosserts to aid you in substantial construction.

The Dossert book gives you full data, not only for the line, but also on wires and cables.

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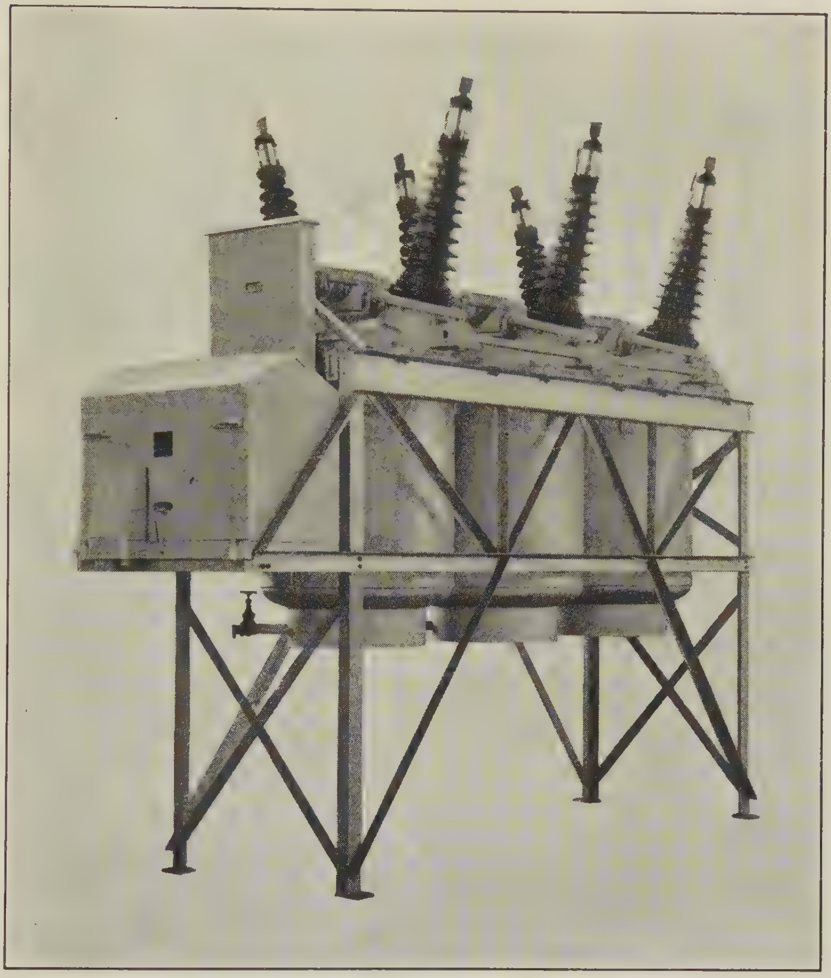
DOSSERT & CO., **H. B. Logan, Pres., 242 W. 41st St., New York**

It's a

DOSSERT

THE NEW PACIFIC ELECTRIC FRAME MOUNTED 69,000 VOLT OIL CIRCUIT BREAKER



PACIFIC ELECTRIC
Type RD-42, 69,000 Volt,
600 Ampere Oil Circuit Breaker
with Type MW-30 Motor Control

Oil Filled Type Bushings.

Complete Phase Isolation.

High Speed on Both Opening and Closing Strokes.

Welded Steel Tops and Tanks.

Hydraulic Tank Hoist.

Motor Wound, Spring Actuated Control.

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Six Horizontal Breaks in Series per Phase.

Sturdy Rolled Bakelite Rotating Unit.

Bus Bar Copper Contact Shoes.

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AMERICAN STEEL & WIRE COMPANY

SUBMARINE CABLES

Strength to Withstand Strain

It is not sufficient that submarine cables transmit current efficiently. In addition, their construction must embody proved principles of construction, to enable the withstanding of terrific strains and stresses. Cables of the American Steel & Wire Company, in use throughout the world, have demonstrated their superiority in every way — rendering longer service and lowering maintenance costs. Whether you need standard or special cables for submarine, overhead or underground use, you will find us ready to serve you efficiently and economically.

What happens when a ship's anchor tangles up with a cable is graphically illustrated here. The cable in question, a product of the American Steel & Wire Company—although badly twisted—continued to operate efficiently.

1831 100 YEARS of PROGRESS IN WIRE MAKING 1931

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208 South La Salle Street, Chicago SUBSIDIARY OF UNITED STATES STEEL CORPORATION And All Principal Cities

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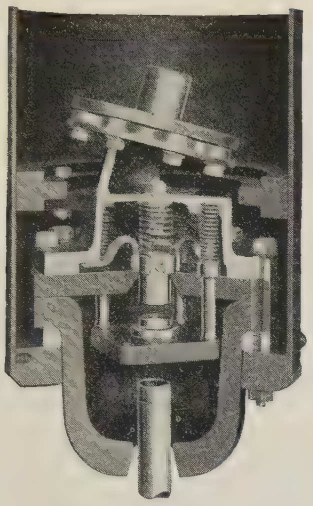
Oil-Blast Explosion Chamber PROVED by these tests



The Philo Station on the 132-kv. system of the Ohio Power Company was used as the proving ground for the new oil-blast explosion chamber. The tests were conducted by courtesy of the American Gas and Electric Company.

Immediately after the 40 tests and before any inspection had been made, the circuit breaker interrupted the charging current of two different lines from the Philo Station four times. The average arcing time was 2.7 cycles with a maximum of four cycles and an average arc length of 3.2 inches.

Rate of recovery voltage rise	Duty	Line volts kv.	Rms. amperes initial in arc	Kv-a. interrupted	Short-circuit duration cycles	Breaker operating time cycles	Arc duration cycles	Arc length in.
270 Volts per microsecond	CO	140	2,550	617,000	5.5	5.2	3.0	4.0
	CO	140	3,450	835,000	5.5	5.2	3.0	4.2
	OCO	140	No current records					
	OCO	140	3,000	725,000	6.0	5.7	3.0	4.5
	CO	140	3,550	860,000	6.0	5.7	2.8	6.0
	CO	140	4,900	1,188,000	6.0	5.2	3.2	5.0
	CO	140	4,450	1,080,000	6.0	5.5	2.5	5.1
	CO	140	4,300	1,042,000	5.0	4.5	1.6	2.7
	OCO	140	4,250	1,030,000	5.0	4.5	2.0	3.0
	CO	140	6,950	1,690,000	6.0	5.2	2.4	5.3
	CO	140	6,350	1,540,000	5.0	4.2	2.0	2.5
	OCO	140	6,800	1,650,000	6.0	5.5	3.0	5.0
	OCO	140	6,550	1,590,000	5.5	4.5	2.4	3.5
	OCO	140	6,550	1,590,000	6.0	5.7	2.9	5.2
	OCO	140	7,150	1,735,000	6.0	5.5	3.0	6.4
600 Volts per microsecond	CO	140	3,250	787,000	7.0	5.7	4.5	8.0
	CO	140	2,700	650,000	7.5	7.0	4.7	9.1
	OCO	140	3,250	788,000	7.0	6.7	3.9	8.0
	OCO	140	3,000	726,000	7.0	6.5	4.0	8.0
	CO	140	3,650	885,000	7.0	6.2	3.7	6.5
	CO	140	3,450	835,000	7.0	6.2	3.5	8.5
	CO	140	4,700	1,140,000	6.0	5.5	2.7	5.3
	CO	140	4,050	983,000	6.0	5.7	2.7	5.5
	OCO	140	3,900	946,000	6.5	5.5	3.6	7.1
2400 Volts per microsecond	CO	140	2,800	680,000	7.0	6.2	4.2	8.5
	CO	140	3,300	800,000	6.5	6.2	4.1	8.2
	OCO	140	3,550	860,000	6.5	6.2	3.5	6.0
	OCO	140	3,100	750,000	7.0	6.5	4.0	8.1
	CO	140	2,100	510,000	8.0	7.2	4.7	10.5
	CO	140	2,700	655,000	8.5	7.7	5.5	11.5
	CO	140	3,100	752,000	7.0	6.2	4.2	8.5
	CO	140	730	177,000	9.0	8.0	5.7	9.3
	OCO	140	800	194,000	8.5	7.2	5.0	8.0
	CO	140	5,300	1,285,000	6.5	6.2	4.0	8.1
	CO	140	4,100	995,000	6.5	5.7	2.7	6.0
	CO	140	4,100	995,000	8.0	7.0	4.6	14.5
	CO	140	3,800	922,000	6.0	5.5	3.2	8.0
	OCO	140	3,650	885,000	6.5	6.0	3.5	6.7
	CO	140	4,500	1,090,000	8.0	7.7	4.4	13.3
	CO	140	4,400	1,068,000	6.5	6.2	3.2	7.0

HERE are tabulated the results of the 40 tests made on a General Electric Type FHKO-139 oil circuit breaker equipped with oil-blast explosion chambers.

A summary shows that, for voltage-recovery rates of 270 and 600 volts per microsecond, the normal condition in actual service, the average arc duration was 3 cycles; the average arc length was 5.6 inches; the time of breaker operation averaged 5.5 cycles; and the line voltage was 140 kv.

Further analysis of the tests shows that, even for a voltage recovery rate of 2400 volts per microsecond, the maximum obtainable and a condition seldom realized in actual service, the arc duration, arc length, and time of breaker operation were consistently small.

The concentration of power for these tests reached a value of nearly 1,750,000 kv-a., the greatest ever made possible for short-circuit tests at any voltage.

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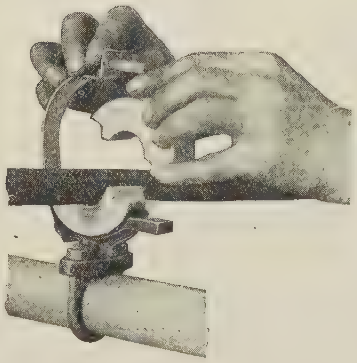
470-23H

GENERAL ELECTRIC
SWITCHGEAR

R&IE
BUS CLAMPS

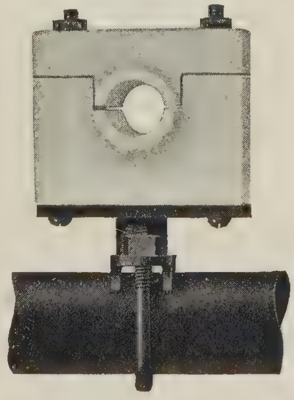
for Wire and Cable

Type "S"



A Bus Support and Cable Clamp of high mechanical strength, wide, round edge clamping surface. Hardware made of non-magnetic parts with single bolt clamp. Easy to assemble.

Cleat Type



Bus Support for high voltage switchboard construction. The advantage of this design is the greater length of the surface leakage path to ground. Round edge clamping surface and adjustable clamping members.

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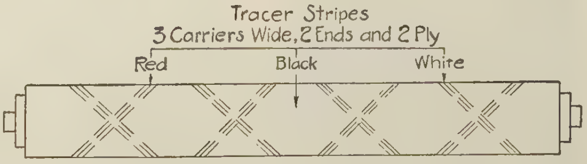
New Color Scheme for CONTROL CABLE



Three Color Tracer Set-Up of Cable No. 22

Base	Tracer	Tracer	Base	Tracer	Tracer
1. Black	.....	.....	19. Blue	Red	.....
2. White	.....	.....	20. Red	Green	.....
3. Red	.....	.....	21. Orange	Green	.....
4. Green	.....	.....	22. Black	White	Red
5. Orange	.....	.....	23. White	Black	Red
6. Blue	.....	.....	24. Red	Black	White
7. White	Black	.....	25. Green	Black	White
8. Red	Black	.....	26. Orange	Black	White
9. Green	Black	.....	27. Blue	Black	White
10. Orange	Black	.....	28. Black	Red	Green
11. Blue	Black	.....	29. White	Red	Green
12. Black	White	.....	30. Red	Black	Green
13. Red	White	.....	31. Green	Black	Orange
14. Green	White	.....	32. Orange	Black	Green
15. Blue	White	.....	33. Blue	White	Orange
16. Black	Red	.....	34. Black	White	Orange
17. White	Red	.....	35. White	Red	Orange
18. Orange	Red	.....	36. Orange	White	Blue
			37. White	Red	Blue

According to a recent announcement, the above color scheme for control cables has been adopted by the N. E. L. A. electrical apparatus committee and the N. E. M. A. power cable group. The list shows the new color and tracer stripe arrangements which are expected to facilitate installation and result in economies of purchase.

Simplex Control Cables conform to the standard color scheme adopted above and may consist of any specified number of conductors, each insulated with a rubber compound and covered with a colored braid. The insulated braided conductors are spiraled together and covered with a tape and braid, or with a tape and lead sheath, as specified.

This type of cable is recommended for the control of electrical apparatus operated at a distant point. It is used to control switches, signal lights, etc., in remote substations that are operated from the main station.

More complete information will be furnished on request.

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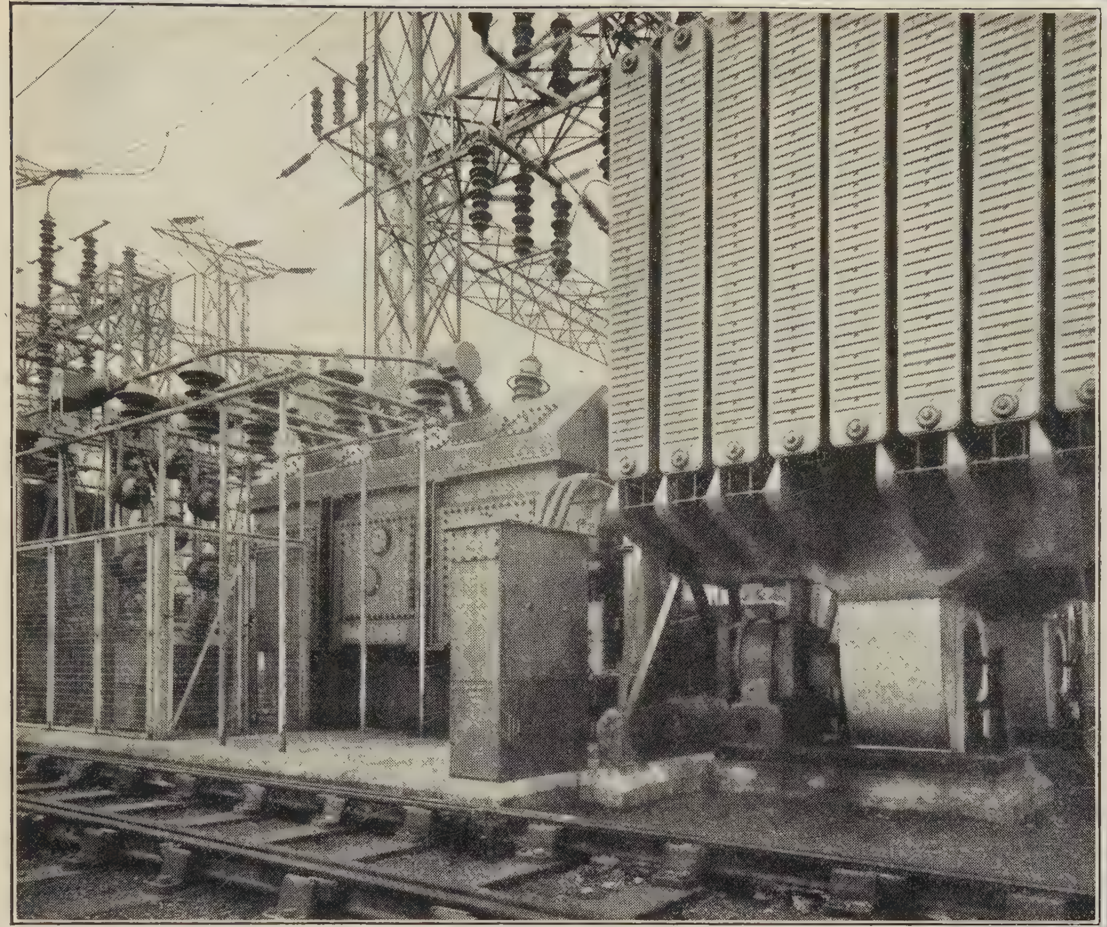

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Designed to give indication of Alternating Current potentials of 2000 Volts and up.

Exact length 24 inches.

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Alternating-current voltmeters employing a copper-oxide rectifier and a d'Arsonval meter movement are, for many purposes, superior to dynamometer instruments. This is so particularly where a wide band of frequencies is to be covered.

The meter illustrated, for example, is accurate to within 2% up to 3000 cycles per second, within 5% to 3000 cycles per second, and within 10% to 10,000 cycles per second. It has a full-scale range of 5 volts and a sensitivity of 2000 ohms per volt.

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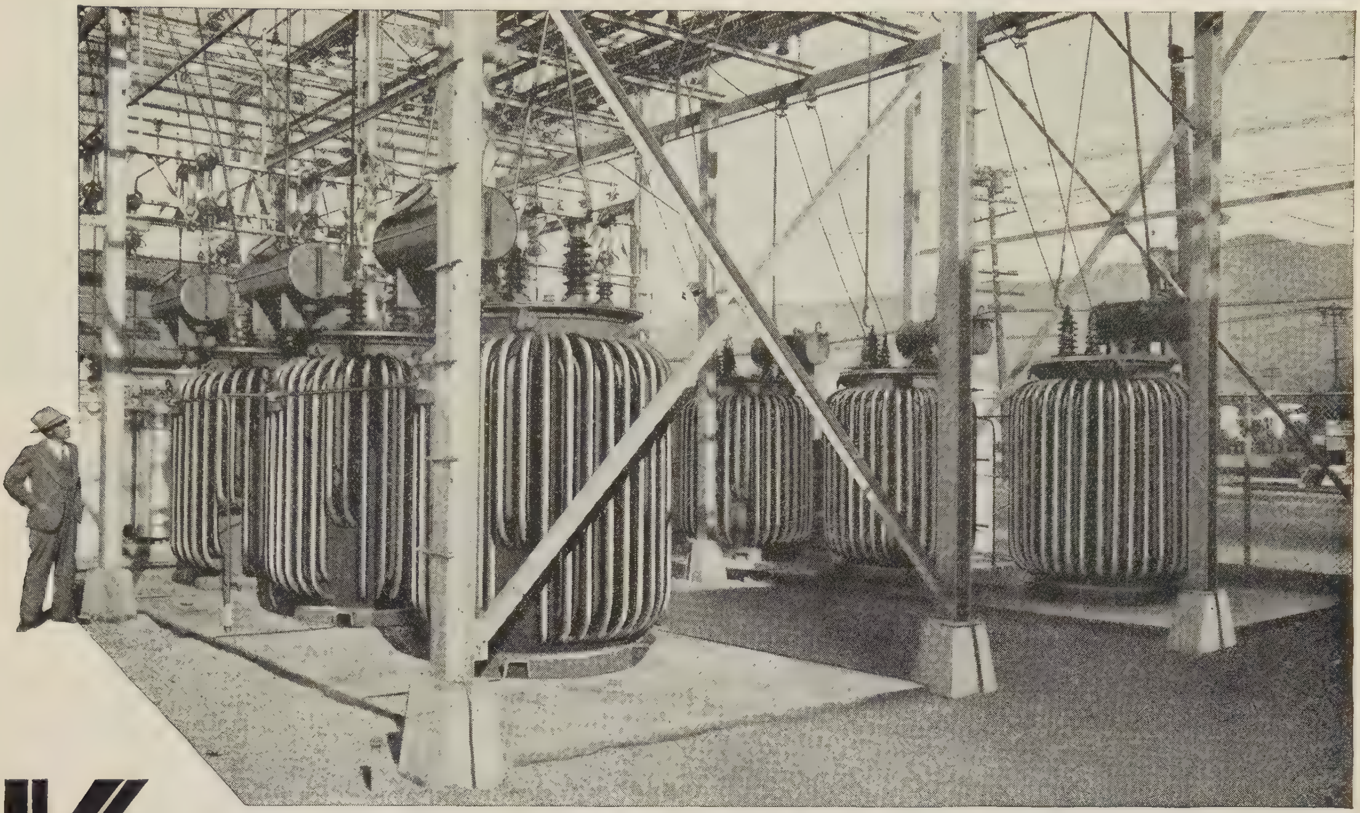

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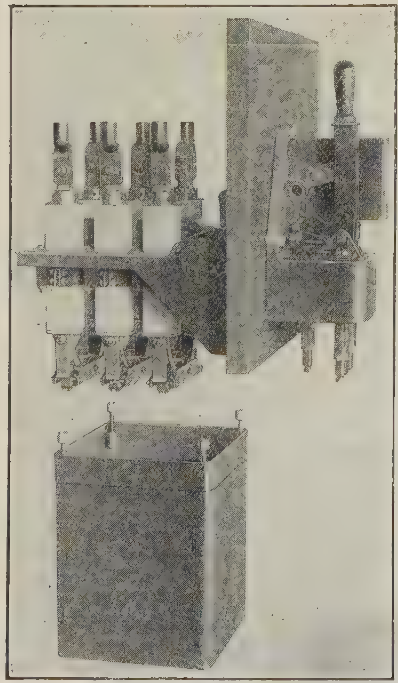

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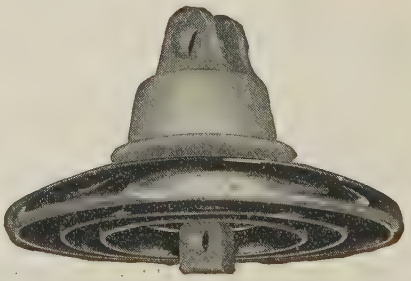

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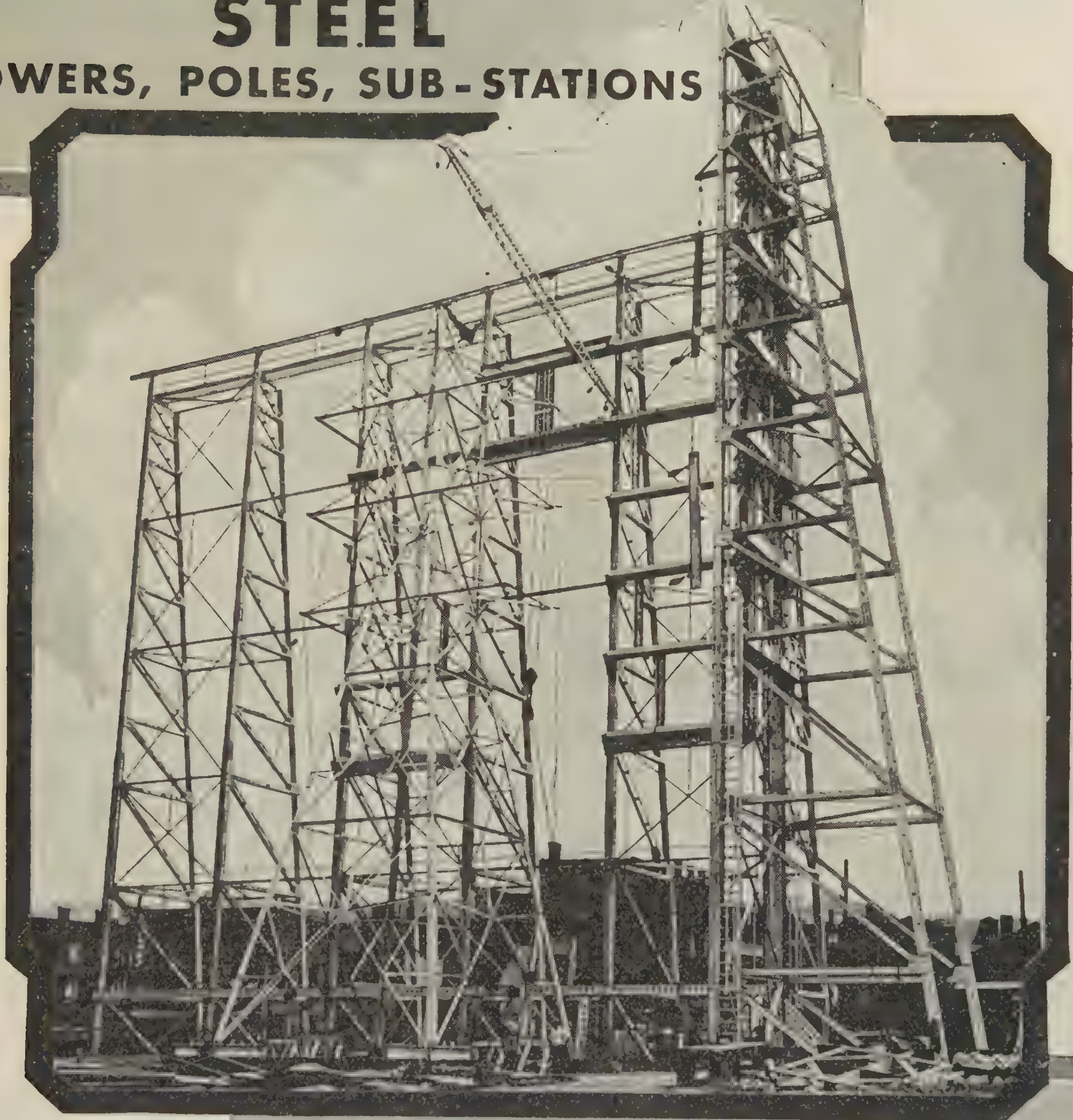

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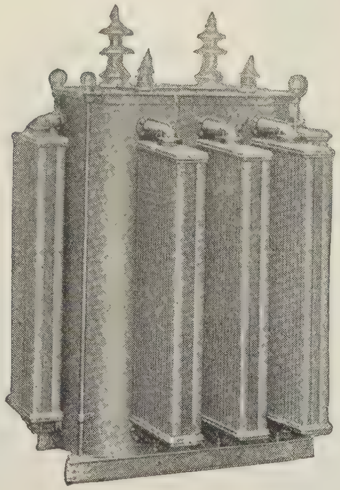

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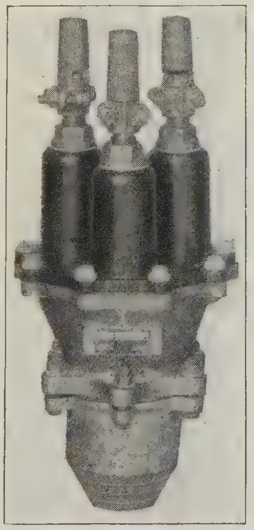

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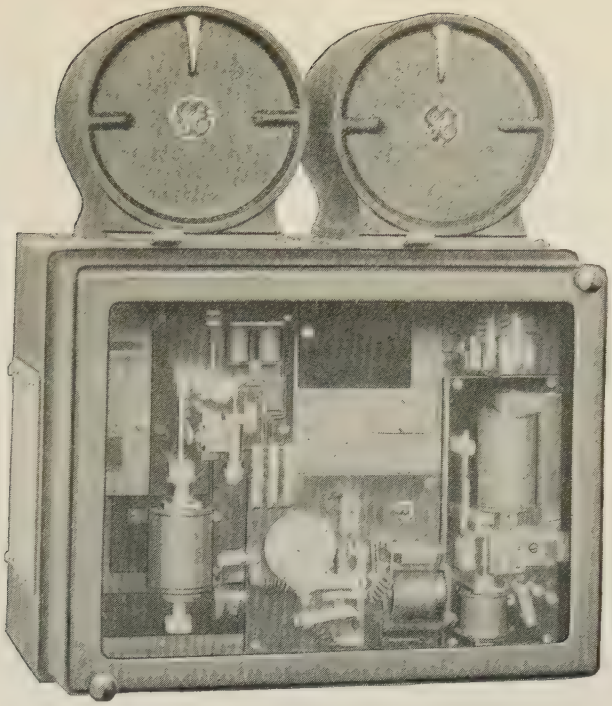

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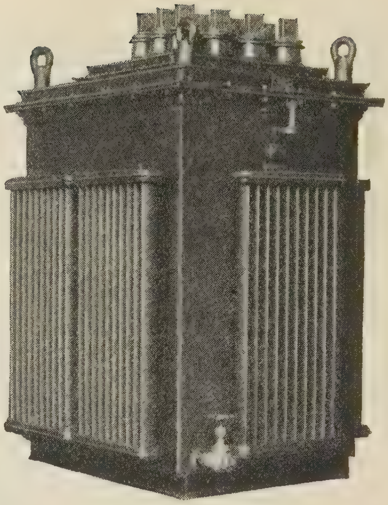

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AmerTran engineers welcome the opportunity of being of service on all transformer problems.

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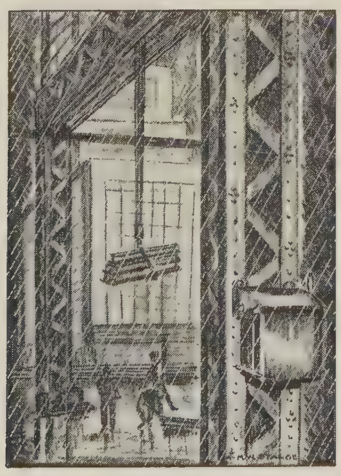
Motor control that is · independent of weather



THERE'S no need to worry about the placing of equipment, if you're figuring on Rowan oil immersed Control.

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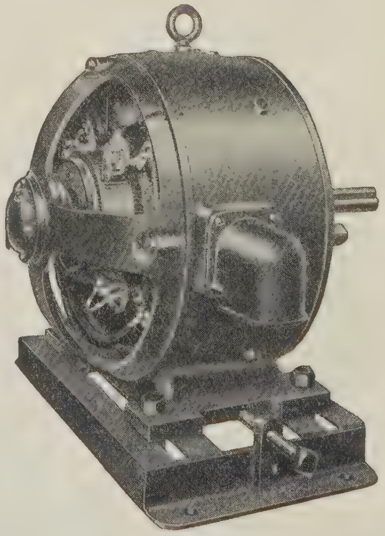

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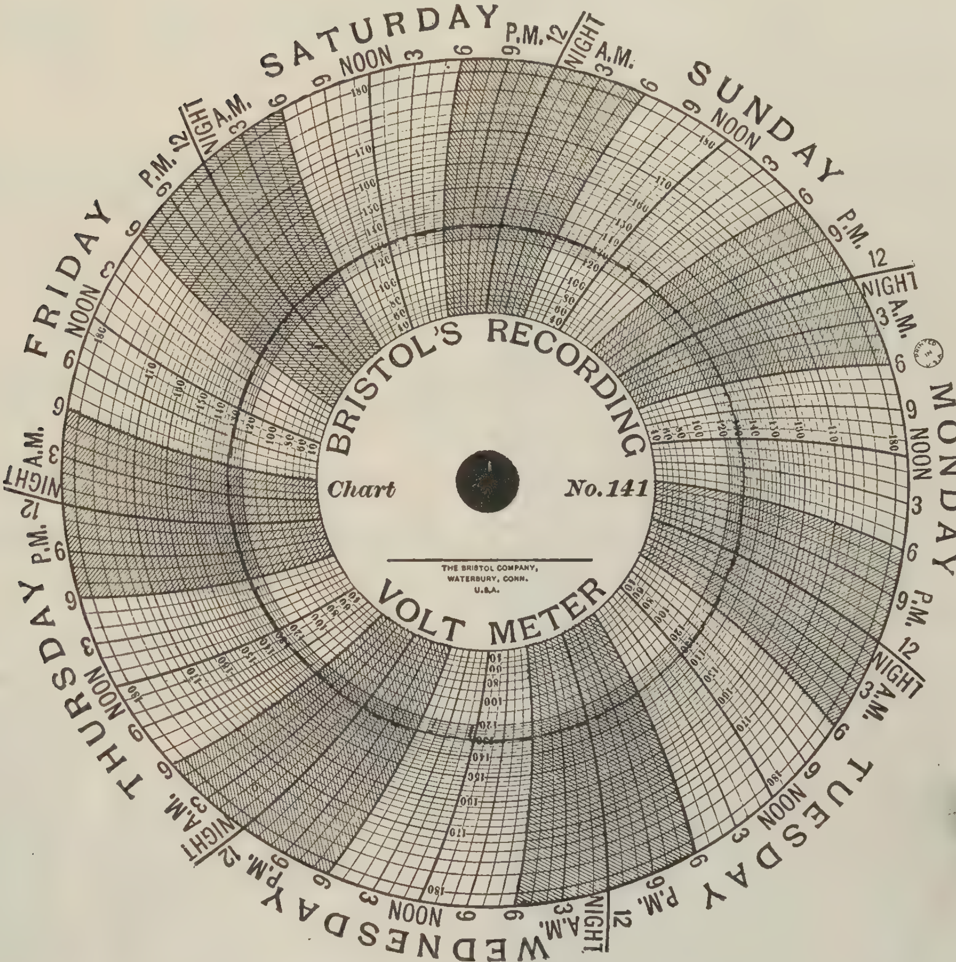

Chart shows normal Diverter Pole Generator performance from February 26 - March 5, 1931, at Magazine Steam Plant of the Southeastern Production Co., near Mobile, Alabama. Generator floating with 60 cells EMGO-9 battery.

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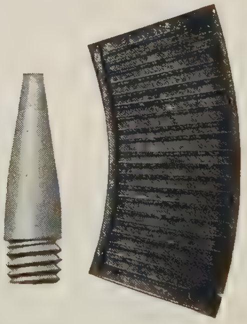

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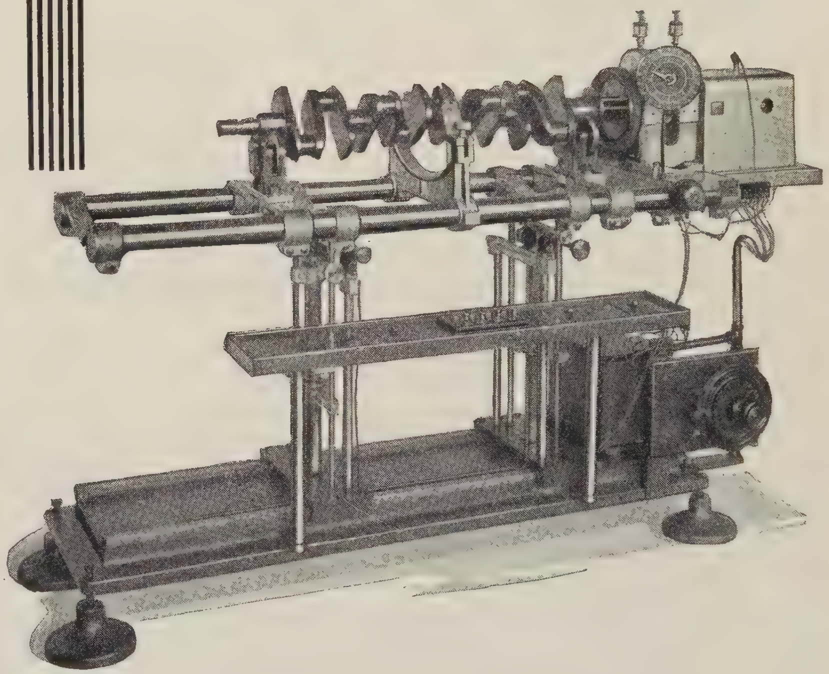

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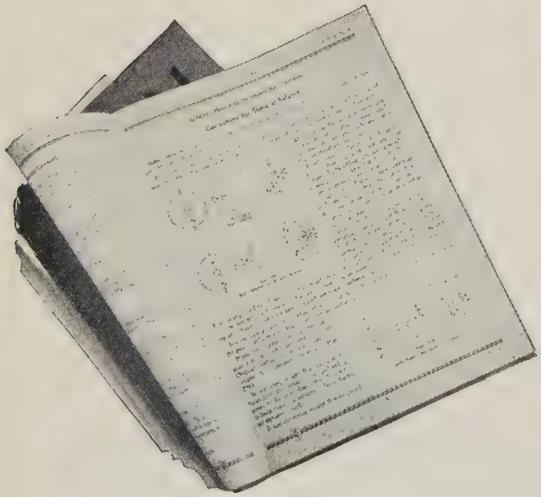

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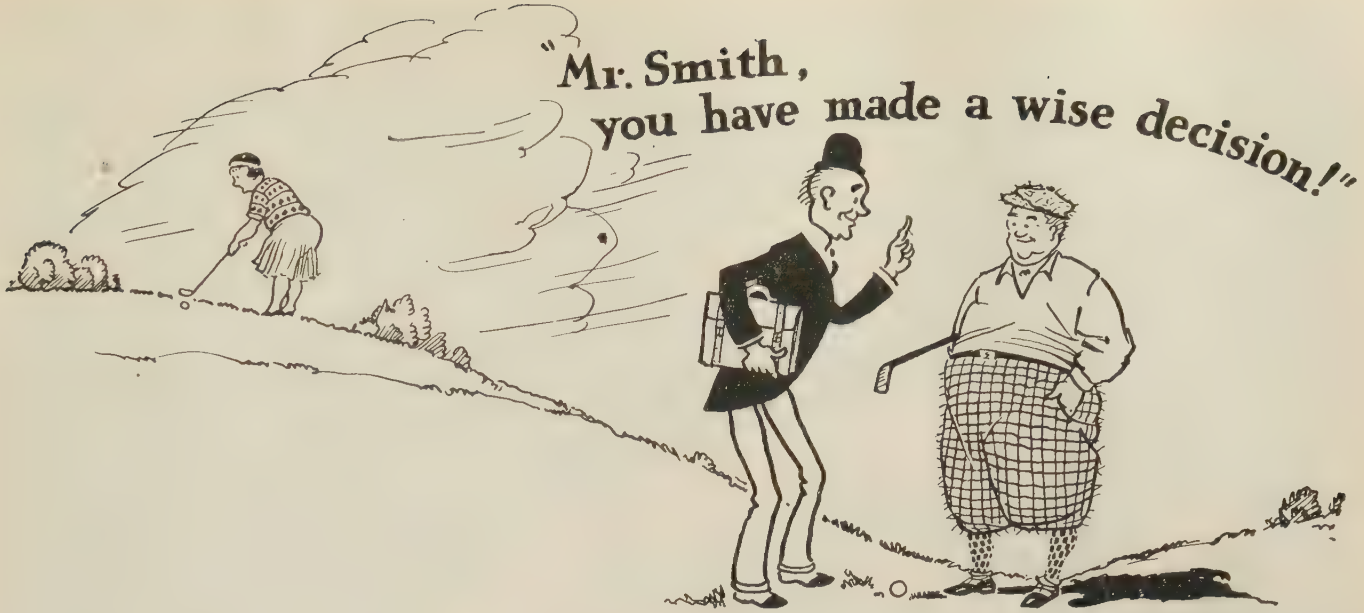
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General Electric Co., Schenectady
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Thomas & Sons Co., R., Lisbon, O.
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Post Type
Delta-Star Electric Co., Chicago
Ohio Brass Co., Mansfield, O.
Railway & Ind. Engg. Co., Greensburg, Pa.
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

INSULATORS, TELEPHONE & TELEGRAPH
Hemingray Glass Co., Muncie, Ind.
Ohio Brass Co., Mansfield, O.

INSULATOR PINS
Ohio Brass Co., Mansfield, O.
Thomas & Sons, Co., R., Lisbon, O.

LADDERS, TRUCK
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LAVA
American Lava Corp., Chattanooga

LIGHTNING ARRESTERS
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General Electric Co., Schenectady
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

LOCOMOTIVES, ELECTRIC
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Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Texas Company, The, New York

MAGNETIC SEPARATORS
Electric Controller & Mfg. Co., Cleveland

METERS, ELECTRICAL
(See INSTRUMENTS ELECTRICAL)

METER SEALS
Metropolitan Device Corp., Brooklyn, N. Y.

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Westinghouse Elec. & Mfg. Co., E. Pittsburgh

MOLDED INSULATION
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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(See GENERATORS AND MOTORS)

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Roller-Smith Co., New York
Weston Elec. Inst. Corp., Newark, N. J.

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Westinghouse Elec. & Mfg. Co., E. Pittsburgh

OIL TESTING SETS
American Transformer Co., Newark, N. J.

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Chandeysson Electric Co., St. Louis
Electric Products Co., Cleveland, O.
Electric Specialty Co., Stamford, Conn.

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Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Malleable Iron Fittings Co., Branford, Conn.

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General Electric Co., Bridgeport, Conn.
Ohio Brass Co., Mansfield, O.

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Ohio Brass Co., Mansfield, O.
Railway & Ind. Engg. Co., Greensburg, Pa.

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PUMPS
Allis-Chalmers Mfg. Co., Milwaukee

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General Radio Co., Cambridge, Mass.
Western Electric Co., All Principal Cities
Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Ohio Brass Co., Mansfield, O.
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Westinghouse Elec. & Mfg. Co., E. Pittsburgh
Weston Elec. Inst. Corp., Newark, N. J.

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Ward Leonard Electric Co., Mt. Vernon, N. Y.

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Westinghouse Elec. & Mfg. Co., E. Pittsburgh

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Kearney Corp., Jas. R., St. Louis

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SPRINGS
American Steel & Wire Co., Chicago

ROEBLING
JOHN A. ROEBLING'S SONS COMPANY
SOLID CONDUCTOR

ROEBLING

Power Cables · Paper; Cambric; Rubber » Submarine Cables » Tree Wire » Parkway Cable » Service Cables » Station Cables » Rubber Covered Control Cables » Rubber Covered Wires and Cables · Braided and Leaded · Code: Intermediate; 30% » Slow-burning Wires and Cables » Weatherproof Wires and Cables » Portable Cords » And a wide variety of other wires and cables.

THE LIST to the left contains merely a few of the many types of electrical wires and cables made by Roebling. From the complete, widely diversified Roebling Line practically any electrical wire or cable need can be fully met.

If you are unfamiliar with these Roebling Products, we would welcome an opportunity to supply complete information—and to demonstrate to you how exceptionally well-made and dependable they are.

Any Roebling office below would be glad to serve you. Stocks of many types of Roebling Wires and Cables are located in the cities listed.

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STOKERS, MECHANICAL
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SWITCHBOARDS
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Knife
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Electrical Testing Labs., New York

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Olsen Testing Machine Co., Tinius, Philadelphia

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General Electric Co., Schenectady

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ETL Know by Test

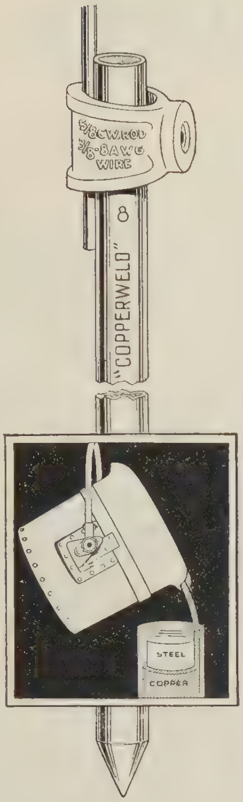
INSPECTIONS TESTS RESEARCH

Testing purchased material places buying on a sound basis.

(1) It determines the quality of competing samples and this enables the purchase of the best quality for the money.
(2) It insures that shipments comply with specifications and assures the customer that shipments match samples.
(3) It furnishes impartial evidence in cases of disputes between purchaser and manufacturer.

ELECTRICAL TESTING LABORATORIES, 80th St. and East End Ave., New York

"COPPERWELD" Ground Rods Are A Proven Standard



Every Copperweld ground rod is a rigid, one-piece rod, pointed, ready for driving with a light hammer.

It is rigid because of the electric furnace steel core. It is non-rusting because the heavy copper exterior is molten-welded to the steel core.

The Copperweld grounding clamp is quickly and easily installed. It maintains a tremendous pressure on the copper-to-copper connection between the grounding wire and the Copperweld rod.

Copperweld Steel Company
Glassport, Penna.

The Nation's Technical Employment Market

IS BROUGHT TO YOUR DOOR through the Engineering Societies Employment Service.

You do not have to take the "best you could get" from a limited local market.

You can procure the right man for the job by availing yourself of the service and resources that are proffered without cost to you. Send your requirements to

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31 West 39th Street, New York City
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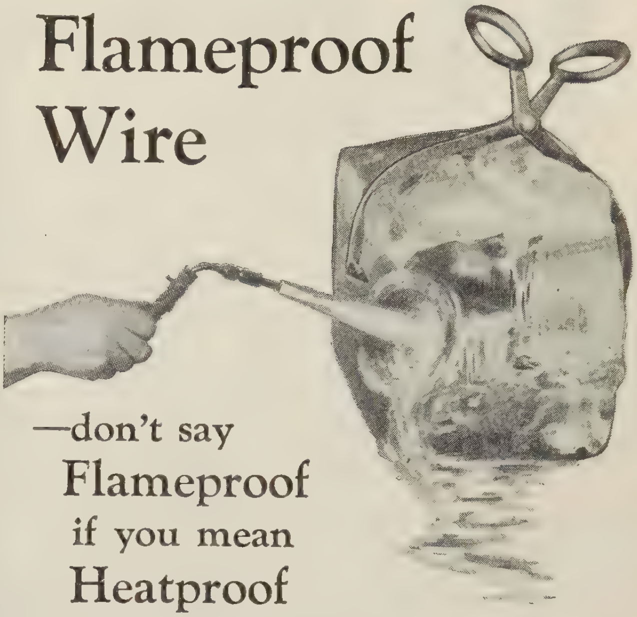
If you use or specify Flameproof Wire



—don't say Flameproof if you mean Heatproof

ICE is "flameproof" according to the generally accepted definition. It won't burn. But it won't last long at temperatures above 32° F. Likewise a "flameproof" wire is not necessarily heatproof. But a real heatproof insulated wire is inherently flameproof.

And a heatproof wire is usually required for most applications where it has been the custom to specify "flameproof"—in rheostats, power feeders, switchboards, etc.

The use of the word "flameproof" is a hand-me-down from times when there were no really heat-proof wires.

But these are now available. They have been made possible by the development of the ROCKBESTOS PROCESS by which asbestos, the basic heatproof material, can be applied to wires and cables of any material and stranding and even to flexible hose for carrying air and liquids.

The felted asbestos walls produced by this process are permanently fireproof, will not deteriorate in any way, even under constantly applied temperatures up to 400° F. and are especially moistureproof impregnated. In combination with varnished cambric they are unaffected by any conduit condition from moisture to 250° F. and when surmounted by a lead sheath, the resultant cable will stay in service without deterioration or failure under conditions ranging from complete submersion to constant temperatures up to 250° F.—a real, trouble-free cable.

Let us send you a set of samples and data. Use the convenient coupon or write:

ROCKBESTOS PRODUCTS CORPORATION
386 NICOLL ST. NEW HAVEN, CONN.

Yes, please send me at no obligation, the samples and data you mention.

Name..........

Company..........

Address..........

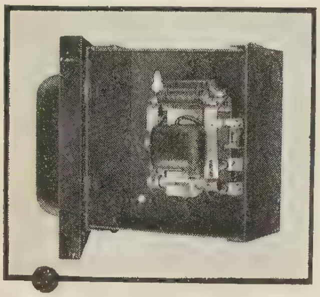
ROCKBESTOS—*the wire with permanent insulation*

14 STANDARD FEATURES AND THEN ADD - ECONOMY

IN selecting equipment to meet the requirements of automatic or remote control problems, the critical buyer demands relays which will "more than do the job." Often satisfactory performance over a period of years depends just as much upon details of construction as upon correct basic design. And to Ward Leonard, the manufacture of relays is much more than a matter of efficient basic design.

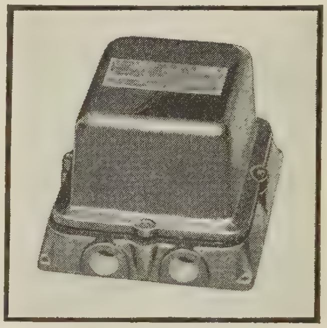
Perfection of detail is the added factor in Ward Leonard relays. Listed among the 14 standard features in Bulletin 81,000 are the fine points of design and construction which satisfy every requirement of the critical buyer.

Send for a copy of this bulletin today. It describes in detail Ward Leonard Magnetic Relays for A. C. and D. C., methods of mounting, and methods of control.



Ward Leonard Relay Mounted in Pressed Steel Box Provided with Mounting Holes and for Conduit Connections.

Specially Designed Coils Used in All Ward Leonard Relays Keep Watts Loss to a Minimum, thereby Conserving Valuable Power. Below:—Ward Leonard Relay Mounted on Cast Aluminum Base with Cast Aluminum Cover.



WARD LEONARD ELECTRIC CO., MOUNT VERNON NEW YORK

WARD LEONARD MAGNETIC RELAYS

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THE UNSEEN

COURIERS

OF THE SPOKEN WORD

THE FAMILIAR TELEPHONE that stands upon your desk at the office or in your home is only a very small part of the great communication system that enables you to talk across the miles with such surprising ease.

Behind it are complicated exchanges, a carefully trained organization of more than four hundred thousand men and women and eighty million miles of wire. These are the forces that make efficient telephone service possible. These are the unseen couriers of the spoken word.

Tirelessly, day or night, without rest or sleep, the Bell System awaits but the lifting of the receiver to carry your voice to any one of thirty-two million other telephone users in this country and abroad, and on ships at sea. It is done so quickly and with so little trouble that few people stop to consider what goes on between the giving of the number and the completion of the call.

Some time every day—perhaps many times a day—you use some part of a telephone system that has taken fifty years and more than four thousand million dollars to build.

The simple words "long distance," which you speak so casually into your telephone, place millions of dollars of equipment at your disposal. Yet the cost of a call from New York to Chicago is only three dollars and but a fraction of that for lesser distances.

Equipment of comparable cost is also needed to connect your home with the thousands or hundreds of thousands of other telephones in your town or city. Yet the charge for local service is only a few cents a day.

In relation to service rendered, the cost of the telephone is one of the smallest items in the monthly business and family budget. Few things purchased are of such real, constant and increasing value.

★ *AMERICAN TELEPHONE AND TELEGRAPH COMPANY* ★

Why tolerate high ground resistance when low ground resistance is readily obtained by using

MURRAY Copper Tube Ground Rods?

Figures given here have been taken from actual field tests of customers:

Before treating	After treating
1275 ohms	110 ohms
1500 ohms	275 ohms
125 ohms	35 ohms
1150 ohms	210 ohms
575 ohms	135 ohms

Dependable low resistance driven grounds in practically any soil are provided at lowest cost by the Murray Copper Tube Ground Rod.

No ground can be considered adequate until verified by test. Soil resistances vary over a wide range in different areas. Identical ground electrodes when separated only a few yards are liable to have a noticeable difference in resistance.

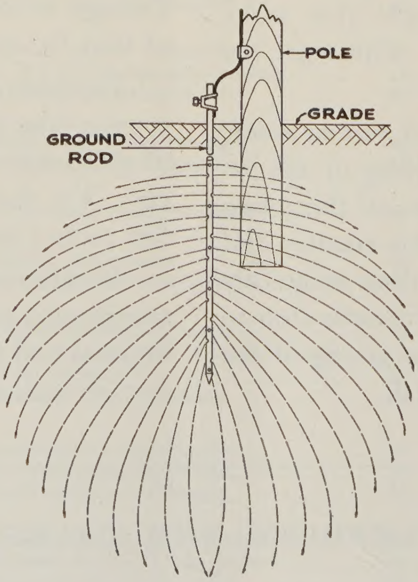
Because of this variation it is imperative that all ground resistances be measured upon the installation of the ground rod and the regular measurements of this resistance be made thereafter.

The Murray Copper Tube Ground Rod is distinctive in that it alone has the feature of regulating the ground resistance of the soil to values suitable or desirable to certain operating conditions.

Our method is a straight-forward, simple and positive one.

To treat the soil around a Murray Copper Tube Ground Rod, a copper sulphate or other solution is poured into the ground rod, which, through ¼ in. holes in the tube is dissipated into the soil surrounding the tube. Treating solutions are evenly distributed the entire depth of the tubing.

Eight page booklet on request. Why not make a trial installation and satisfy yourself that this is the best grounding system obtainable?



MURRAY COPPER-TUBE GROUND RODS

REGULATE YOUR GROUND RESISTANCE

METROPOLITAN DEVICE CORPORATION

1250 ATLANTIC AVE., BROOKLYN, N. Y.

THE OKONITE COMPANY

announces

OKOSHEATH

A non-metallic, sheathed cable

Okosheath Cable has features never before combined in any underground cable. Simple as a pencil — your linemen can splice it. Its simplicity, light weight, flexibility, toughness, waterproofness, and resistance to the chemicals in soil or conduit make it of vital interest to all operating men.

This uniquely designed cable fits directly into present day power problems. It affords economies and ease of installation in secondary networks and other low voltage distribution uses.

As Simple as a Pencil

THE OKONITE COMPANY
Founded 1878
THE OKONITE-CALLENDER CABLE COMPANY, INC.
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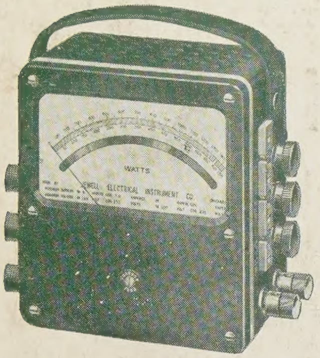
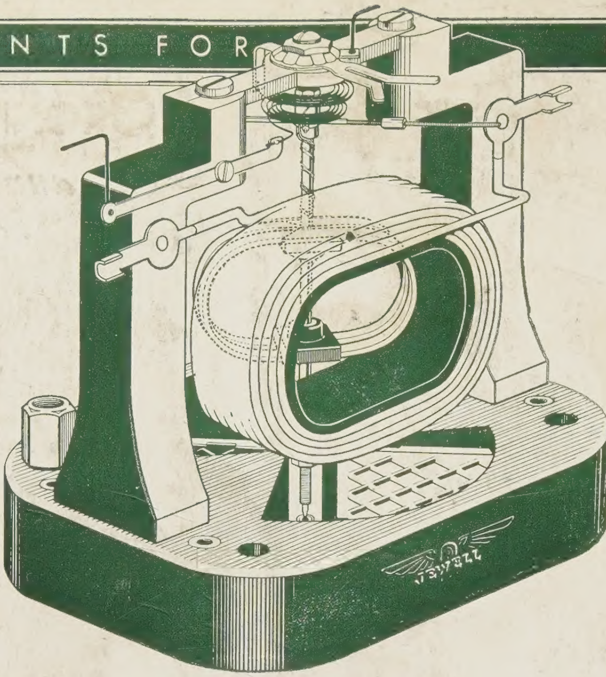
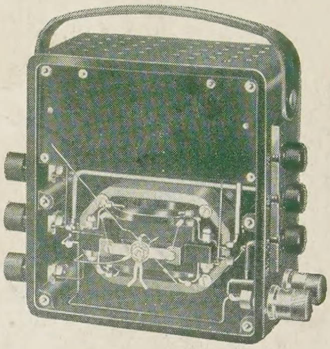
INSTRUMENTS FOR INDUSTRY


The remarkably large scale opening enclosed with non-shatterable glass makes it easy to read Jewell Master Instruments.




The Style L Dynamometer movement is mounted in a dust-tight, bakelite case with resistances in a separate ventilated compartment.

The STYLE L MOVEMENT
in Master Portable Wattmeters
is a triumph of instrument design

JEWELL

MASTER INSTRUMENTS

- Pattern 170— Current Transformer
- Pattern 171— D. C. Voltmeter or Ammeter
- Pattern 172— A. C. Voltmeter or Ammeter
- Pattern 173— Single Phase Wattmeter
- Pattern 174— VoltAmp Wattmeter
- Pattern 175— Polyphase Wattmeter
- Pattern 176— Thermal Voltmeter

Tucked away in the case of the Jewell Master Portable Wattmeter is the Jewell Style L Dynamometer Movement, recognized universally as a triumph of instrument design!

It is easy to become enthusiastic about the Jewell Dynamometer Movement. This sensitive, but amazingly rugged unit has made possible single and polyphase wattmeters that maintain their high accuracy in spite of the hard treatment which they receive in portable testing service.

There are many unusual refinements, such as the extensive use of molded bakelite for fan boxes, supporting pillars, coil supports, and covers. Magnetic shields prevent external fields from affecting the instrument. The moving element with its double aluminum damper fans is "dead beat."

An important feature of all Master Portable Instruments is the wide scale opening, covered with non-shatterable glass; and the attractive bakelite cases that withstand wear and tear better than the best mahogany.

Write for the Jewell Master Instrument Catalog today.

Jewell Electrical Instrument Co., 1650 Walnut Street, Chicago, Ill.

31 YEARS MAKING GOOD INSTRUMENTS

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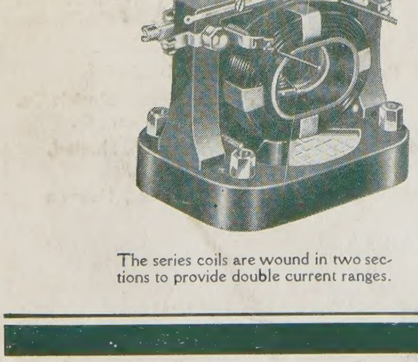
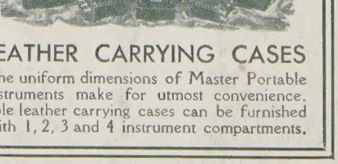
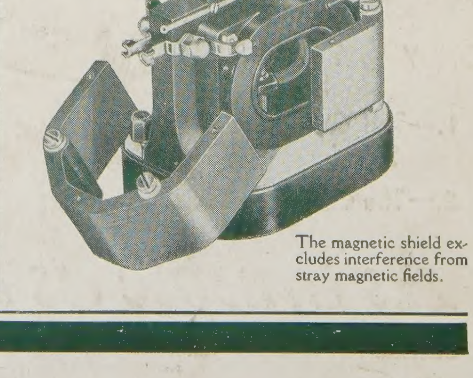

The series coils are wound in two sections to provide double current ranges.


LEATHER CARRYING CASES

The uniform dimensions of Master Portable Instruments make for utmost convenience. Sole leather carrying cases can be furnished with 1, 2, 3 and 4 instrument compartments.


The magnetic shield excludes interference from stray magnetic fields.